

Reference

FM 5-26

DEPARTMENT OF THE ARMY FIELD MANUAL

**EMPLOYMENT
OF
ATOMIC DEMOLITION
MUNITIONS (ADM)**

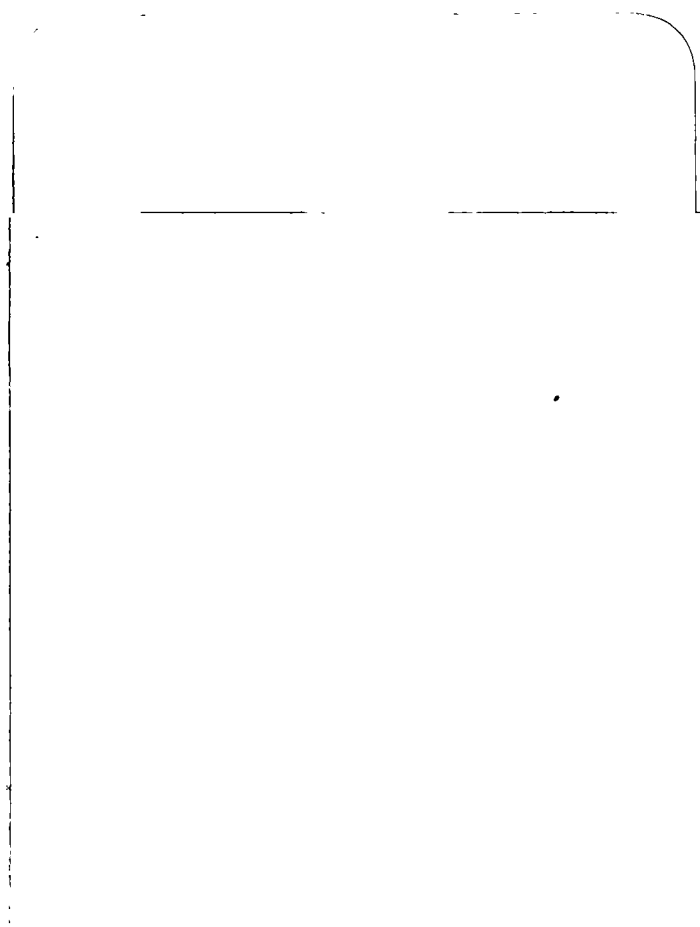


**HEADQUARTERS, DEPARTMENT OF THE ARMY
DECEMBER 1965**



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CHANGE

No. 2

HEADQUARTERS
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WASHINGTON, D.C., 24 January 1969

EMPLOYMENT OF ATOMIC DEMOLITION MUNITIONS (ADM)

FM 5-26, 7 December 1965, is changed as follows:

1. Remove old pages and insert new pages as indicated below.

Old pages	New pages
1-1 and 1-2	1-1 and 1-2
3-5 and 3-6	3-5 and 3-6
3-13 and 3-14	3-13 and 3-14
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5-1 and 5-2	5-1 and 5-2
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A6-1 through A6-6	A6-1 through A6-5
A7-1 through A7-9	A7-1 through A7-7

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By Order of the Secretary of the Army:

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CHANGE

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1. Remove old pages and insert new pages as indicated below.

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2-1, 2-2	2-1 through 2-2.1
3-5, 3-6	3-5, 3-6
3-9, 3-10	3-9, 3-10
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AI-1 through AI-3	AI-1 through AI-3
A6-3 and A6-4	A6-3 through A6-4
A8-1 through A8-6	A8-1 through A8-5

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FIELD MANUAL

No. 5-26

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 7 December 1965

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CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual provides guidance for tactical commanders and staff officers in the operational and logistical aspects of atomic demolition munitions (ADM) employment. In addition, ADM target analysis techniques and emplacement methods are discussed for engineer personnel and nuclear weapons employment officers.

1-2. Scope and Organization

a. The doctrine presented in this manual is primarily concerned with ADM employment within the field army area (combat zone).

★*b.* This manual is in consonance with the following International Standardization Agreements which are identified by type of agreement and number at the beginning of each appropriate chapter in the manual: STANAG (SEASTAG) 2017 Orders to the Demolition Guard Commander and Demolition Firing Party Commander; STANAG 2104 Friendly Nuclear Strike Warning to Armed Forces Operating on Land; STANAG 2130 Employment of Atomic Demolition Munitions (ADM).

c. This manual presents only that material which is applicable to ADM employment and emplacement for surface or subsurface bursts.

d. Complete coverage of ADM employment, operational concepts, and target analysis is provided in two separate field manuals:

(1) This manual provides doctrine concerning those unclassified facets of ADM operations applicable to active nuclear warfare. It contains U.S. Army concepts for ADM employment, and the command and staff actions required to carry out those concepts. In addition, detailed procedures regarding ADM target analysis techniques are presented in this text

as well as methods of ADM emplacement. This text presents data concerning a family of hypothetical atomic demolition munitions designed specifically for use in unclassified ADM instruction. Illustrative problems in target analysis employ unclassified data extracted from these hypothetical effects tables.

(2) Classified defense information concerning ADM currently within the United States stockpile is included in FM 101-31-2. It provides tabular data necessary for target analysis and presents items of information concerning technical procedures which are not a part of this manual because of security classification. This manual is also designed for active nuclear combat.

(3) The organization of the ADM effects tables in both texts is similar. Differences in data between United States stockpile ADM and the family of hypothetical ADM are intentional in order to protect the security of actual ADM. Proficiency in the use of hypothetical effects tables, however, insures facility in the use of the actual effects tables.

e. This manual repeats information presented in other military publications only as required for clarity or consistency. Consequently, this manual should be used in conjunction with other applicable military publications (see app I).

1-3. Changes

Users of this manual are encouraged to recommend changes or provide comments to improve its clarity or accuracy. Comments should be keyed to the specific page, paragraph, and line of the text to which they refer. Reasons should be provided for each comment to insure understanding and permit complete evaluation. Comments should be forwarded directly to the

Commanding Officer, U.S. Army Combat Developments Command Engineer Agency, Fort Belvoir, Virginia 22060. Originators of proposed changes which would constitute a significant modification of approved Army doctrine may send an information copy, through command channels, to the Commanding General, U.S. Army Combat Developments Command, Fort Belvoir, Virginia 22060, to facilitate review and follow-up.

1-4. Concepts of ADM Employment

The doctrine in this manual is based on the following national policy and concepts:

a. The U.S. Army is organized and equipped to fight in nuclear and in nonnuclear war or under the threat of nuclear warfare.

b. ADM are employed within the theater of operations in accordance with national policy and when their use is authorized by the theater commander.

c. Once the use of ADM has been authorized, responsibility for ADM employment is normally decentralized to the lowest tactical echelon capable of conducting ADM mission planning, coordination, and execution.

d. ADM are employed against materiel targets rather than personnel thus constituting an addition to the present family of military explosives. Their use parallels or complements those of conventional demolitions. Employment of ADM rather than conventional explosives is usually dictated by the resultant savings in time, manpower, and logistical effort.

e. ADM are employed in conformance with tactical requirements to deter the enemy and deny the use of key structures and installations

such as dams, bridges, and industrial facilities. Lowest possible yields consistent with military and political necessity are employed to prevent civilian casualties, overdestruction of manmade and natural features, or unacceptable radiation hazards.

f. A commander employing ADM coordinates with unit commanders in whose area militarily significant nuclear effects are expected to extend. Lacking concurrence, authorization to employ the demolition is requested from the commander who exercises military control over both affected areas.

g. ADM are closely related to the family of nuclear weapons because of their nuclear characteristics and consequent massive destructive potential. In this regard, ADM are subjected in large measure to the same command and control procedures developed for nuclear weapons; i.e., mission planning, security, logistics, troop safety, target analysis, and authority to fire.

1-5. System of Measurement

In accordance with paragraph 18.1, C 6, AR 310-3, tabular data for nuclear blast, thermal, and radiation effects, minimum safe distances, and related contingency effects are expressed in the metric system of measurement. However, to facilitate target analysis procedures, cratering data applicable to the demolition of structures and creation of terrain obstacles are expressed in both the English and metric measurement systems. Appendix V contains tabular data to assist in converting from one measurement system to the other when the need arises.

CHAPTER 2

EFFECTS OF NUCLEAR EXPLOSIVES

Section I. GENERAL

2-1. Introduction

a. The employment of ADM requires a basic understanding of nuclear effects, particularly those resulting from subsurface bursts; the response of targets to these effects; the distance at which secondary damage or casualties may be expected; the influence of various environmental conditions; and the variability of predicted results.

b. This chapter presents a general qualitative discussion of the nuclear effects of ADM and their military significance; TM 23-200 should be consulted for details regarding specific nuclear phenomena.

2-2. Description of Nuclear Detonations

a. *Release of Energy.* Two types of nuclear reactions produce energy, fission and fusion. The energy released (yield) by either type reaction is measured in thousands of tons of TNT energy equivalent (kiloton or kt) or in millions of tons of TNT energy equivalent (megaton or mt).

b. *Effects Produced.* Transfer of energy from an ADM detonation to the surrounding media begins immediately after detonation and is usually exhibited in four distinct forms—

- (1) *Blast or ground shock.* Mechanical shock effects are produced by a high pressure impulse or wave as it travels outward from the point of detonation (burst point).
- (2) *Thermal radiation.* Heating effects result as objects in the surrounding area absorb thermal energy released by the burst.
- (3) *Nuclear radiation.* Ionization of the surrounding media occurs when nu-

clear radiation emitted by the burst is absorbed. This results in residual radiation being emitted by the material so ionized.

- (4) *Cratering.* Material near the munition is crushed, fractured, and displaced with large quantities being ejected beyond the immediate area of the point of detonation.

★ c. *Energy Coupling.* The degree to which the energy from a surface or subsurface ADM detonation is transferred, or coupled, to the surrounding earth depends on depth of burst, the properties of the soil or rock in the vicinity of the device, and the manner in which the device is tamped or stemmed. The degree of coupling determines the amount of energy released to the atmosphere, and the amount used in crater formation.

2-3. Damage Criteria and Radius of Damage

a. *General.* Data pertinent to the military employment of nuclear explosives have been developed through tests. These include—

- (1) The magnitude of effects required to cause a particular degree of damage to a given target.
- (2) The distance to which any given magnitude of effects extends from a given point of detonation and/or ground zero.

b. *Damage Estimation.* The prediction of the condition of a target after it has been attacked is termed damage estimation.

c. *Degrees of Damage.* Damage to materiel targets is classified as severe, moderate, or light. These degrees of damage are described as follows (for further details, see app III) :

- (1) Light damage does not prevent the immediate use of an item although minor repair may be required to make full use of the item.
- (2) Moderate damage prevents full use of an item until extensive repairs are made. This degree of damage is normally sufficient for most denial type targets composed of military equipment or supplies.
- (3) Severe damage permanently prevents use of the item. Repair in this case is generally impossible or more costly than replacement. Normally, this is the criterion for hard targets such as field fortifications, dams, or bridges.

d. Radius of Damage. The radius of damage (R_D) is the distance to which a specific effect extends. For each yield and point of burst, the R_D varies with the degree of damage desired and the type target. *For example*, the R_D for moderate damage to wheeled vehicles differs from that for severe damage as does the R_D for severe damage to field fortifications. A detailed discussion of predicted target coverage is contained in FM 101-31-1.

2-4. Types of Bursts

Nuclear detonations may occur at any point from deep below the earth's surface to high in the atmosphere. Tactically, nuclear

bursts are classified according to the manner in which they are employed; that is, air defense, high air, low air, surface, and subsurface. Types of burst normally applicable to ADM employment are subsurface and surface bursts.

★ *a. Subsurface Burst.* This type of burst (less than zero height) is used to cause damage to underground targets and to maximize cratering effects. The subsurface burst provides flexibility for the control of both initial and residual nuclear effects along the surface or in the atmosphere. *For example*, at optimum depths of burial for cratering, thermal radiation is eliminated, initial nuclear radiation and airblast are severely curtailed, and downwind distance of zones I and II for fallout are reduced to approximately ten percent of that from a surface burst; moreover, in the case of subsidence craters (surface cave-in), nuclear effects on the surface are virtually eliminated.

b. Surface Burst. This type of burst (zero height) occurs when an ADM is detonated at ground level. This type burst is used to destroy targets susceptible to high blast overpressures, thermal radiation, cratering, and ground shock. Whenever fallout is not a limiting factor, the surface burst may be used; however, if fallout is desired as a bonus effect, slightly burying the ADM significantly enhances the fallout produced.

Section II. BLAST

2-5. Airblast and Ground Shock

Airblast accompanies all types of bursts except for a completely contained detonation.

a. An airburst produces a slightly greater radius of damage against targets vulnerable to low overpressures than would an equivalent-yield surface burst.

b. A surface burst, however, is more effective against most military *demolition targets* because of the immediate reflection and reinforcement of the blast wave by the earth's surface, thereby resulting in greater ranges for *high* overpressures.

c. A subsurface burst produces the least

blast damage to military targets above ground since the major part of the total energy is used in cratering or is transmitted as ground shock. The deeper the ADM is emplaced, the less airblast is produced. Chapter 7 discusses reduction in blast damage radii for various depths of burial.

2-6. Damaging Pressures

As the blast wave moves outward in all directions, it exerts two types of damaging pressures on materiel targets in its path—

a. Overpressure. This is a squeezing or crushing force which surrounds the object and continues to apply force from all sides

until the pressure returns to normal. At any given point away from ground zero, the highest overpressure reached during passage of the blast wave is called the peak overpressure for that point. Targets which are sensitive to, and are damaged primarily by, overpressures are called *diffraction targets*.

b. *Dynamic Pressure*. As the blast wave

moves away from the burst point, it is accompanied by high winds. Dynamic pressure is a measure of the forces associated with these winds. This pressure causes damage by pushing, tumbling, or tearing apart target elements. Targets which are damaged by dynamic pressure are called *drag-type targets*. Most materiel targets are drag-sensitive.



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2-7. Ground Target Response to Blast

The blast effect of an ADM is important as a damaging agent against materiel targets. Since the cratering effect extends for comparatively short distances, blast may be the only effective damage-producing mechanism against area targets. Most military equipment is drag-sensitive and is damaged primarily by dynamic pressure. Parked aircraft, buildings, and forests are damaged by a combination of overpressure and dynamic pressure, whereas land mines are detonated solely by overpressure. (For further details, see app. III.)

2-8. Ground Shock

In general, ground shock may be likened to the blast wave phenomenon except that it

travels through the earth. Like the blast wave, this shock wave travels outward from the point of detonation. The degree of transmission is dependent upon the soil properties and, in all cases, is attenuated much more rapidly than is air blast. As a result the distance to which militarily significant damage to an underground target occurs does not generally extend beyond the plastic zone (see para. 2-18). Within the region of the rupture and plastic zones, however, sufficient damage to most underground structures occurs to seriously impair the operational capability of personnel and equipment, although weak, shallow buried structures and some utility pipelines may be damaged by induced ground shock as the blast wave passes over the surface.

Section III. THERMAL RADIATION

2-9. General

Thermal radiation is the heat and light produced by a nuclear explosion and may extend to great distances dependent on the yield of the munition and the type of burst. Within the atmosphere, thermal radiation exhibits characteristics similar to those of light. *For Example—*

- a. Both light and thermal radiation travel at the same velocity.
- b. Both travel in straight lines unless scattered or reflected.
- c. Both are easily absorbed or attenuated.

2-10. Effect of Depth of Burst on Thermal Radiation

a. Approximately 35 percent of the total energy released by a nuclear detonation in free air is emitted from the fireball in the form of thermal radiation (ultraviolet, visible, and infrared). The intensity of the thermal radiation received at a given location from a surface nuclear detonation is less than that received from an air burst of the same yield because of attenuation by dust and water vapor in the atmosphere close to the earth's surface. Thermal radiation from a surface burst is reduced by 25 percent at short distances and at longer distances by as much as

50 percent of that produced by an equivalent yield air burst.

b. In subsurface bursts, if the fireball is contained underground, practically all thermal radiation released by the detonation is used in the vaporization and melting of the media surrounding the device. Even for shallow depths of burst in which a portion of the fireball extends above the ground surface, the intensity of thermal radiation emitted is considerably less than for a surface burst. (For further details, see ch. 7.)

2-11. Military Significance of Thermal Radiation

a. Thermal radiation may constitute either a bonus effect or a hazard with regard to ignition of forest or urban areas.

b. When considering the safety of friendly troops, thermal radiation is an important factor since second degree burns may produce noneffectives.

c. Dazzle (temporary loss of vision) during daylight is usually not an important consideration. However, at night, loss of night vision may reduce combat effectiveness. To minimize the effect of dazzle and the number and severity of retinal burns, troops within the limit of visibility are warned, whenever possible, prior to the detonation.

Section IV. NUCLEAR RADIATION

2-12. Initial Radiation

a. Initial nuclear radiation is defined as that nuclear radiation which is emitted by a nuclear detonation *within* the first minute after the burst. Nuclear radiation emitted after 1 minute is termed residual radiation.

b. Nuclear radiation consists of a flow of subatomic particles such as neutrons, alpha and beta particles, and gamma rays. Alpha and beta particles have a short range with little penetration capability; they are of no major significance unless beta emitters come in contact with the skin, or both alpha and beta emitters are inhaled or ingested. On the other hand, neutrons and gamma rays have a range measured in hundreds or thousands of meters and are highly penetrating. Because of these ranges and penetration properties, only neutrons and gamma rays are considered in evaluating the effects of initial nuclear radiation.

c. Since neutrons and gamma rays collide with other particles in the atmosphere, they quickly become scattered in all directions. This particular characteristic makes it difficult to achieve adequate protection from initial nuclear radiation. Moreover, the high penetrating power of gamma rays and neutrons makes adequate personnel protection even more difficult to obtain.

2-13. Residual Radiation

Residual radiation consists primarily of gamma rays and beta particles from neutron induced radioactive soil elements and fallout. Hazardous terrain areas from induced radiation are limited to a relatively small area around ground zero. Fallout, however, is characterized by an irregular pattern of hazardous radioactive contamination encompassing ground zero and extending downwind from ground zero, the distance depending upon the yield, wind conditions, and depth of burst. Residual radiation from this fallout contamination may also cause the airspace over the area of operations to be hazardous for limited periods of time while the fallout is being

transported downwind and deposited on the ground.

2-14. Effect of Depth of Burst on Nuclear Radiation

With surface and shallow subsurface bursts, both initial and residual nuclear radiation effects are important factors. For deeper subsurface bursts, however, initial radiation is absorbed by surrounding media. In this situation, the radioactive material which escapes to the atmosphere is the only type of radiation hazard that need be considered. Furthermore, the residual radiation hazard area coverage for a specific ADM detonation will depend largely on the depth of burial and selected yield.

2-15. Radiation Measurement

For scientific and technical purposes, nuclear radiation is measured in a variety of units. For practical military use, however, all types of radiation are measured in *rad* which is a unit of measure for *absorbed* doses of radiation. A rad represents 100 ergs of nuclear (or ionizing) radiation per gram of the absorbing material or tissue.

2-16. Military Significance of Nuclear Radiation

a. Induced radiation persists for a period of days; and, in general, decontamination is quite difficult. Consequently, the presence of induced radiation in the immediate vicinity of ADM targets enhances their obstacle value. On the other hand, the relatively small area affected may be easily bypassed if the terrain permits.

b. The large area contamination potential of fallout can introduce a significant operational difficulty or constitute a bonus effect.

c. With minor exceptions, nuclear radiation has no destructive effect against materiel targets.

d. The casualty producing potential of nuclear radiation makes it an extremely important troop safety consideration. (For further discussion, see para. 5-7 and ch. 7.)

Section V. CRATERING

2-17. General

When the ADM is detonated below or on the surface, the material near the munition is crushed, fractured, displaced, and some of it is fused. Great quantities of earth and rock are thrown out of the ground. Some of this material falls back into the resulting crater; most of the remainder falls onto the ground outside the crater although a small portion

of the finer particles is carried up in a large dust cloud and is eventually deposited as fall-out. The resulting crater is roughly parabolic in section (fig. 2-1). Its dimensions depend mainly on the yield of the detonation, the depth of burst, and the characteristics of the soil media. (See sec. II, ch. 6, for further discussion.)

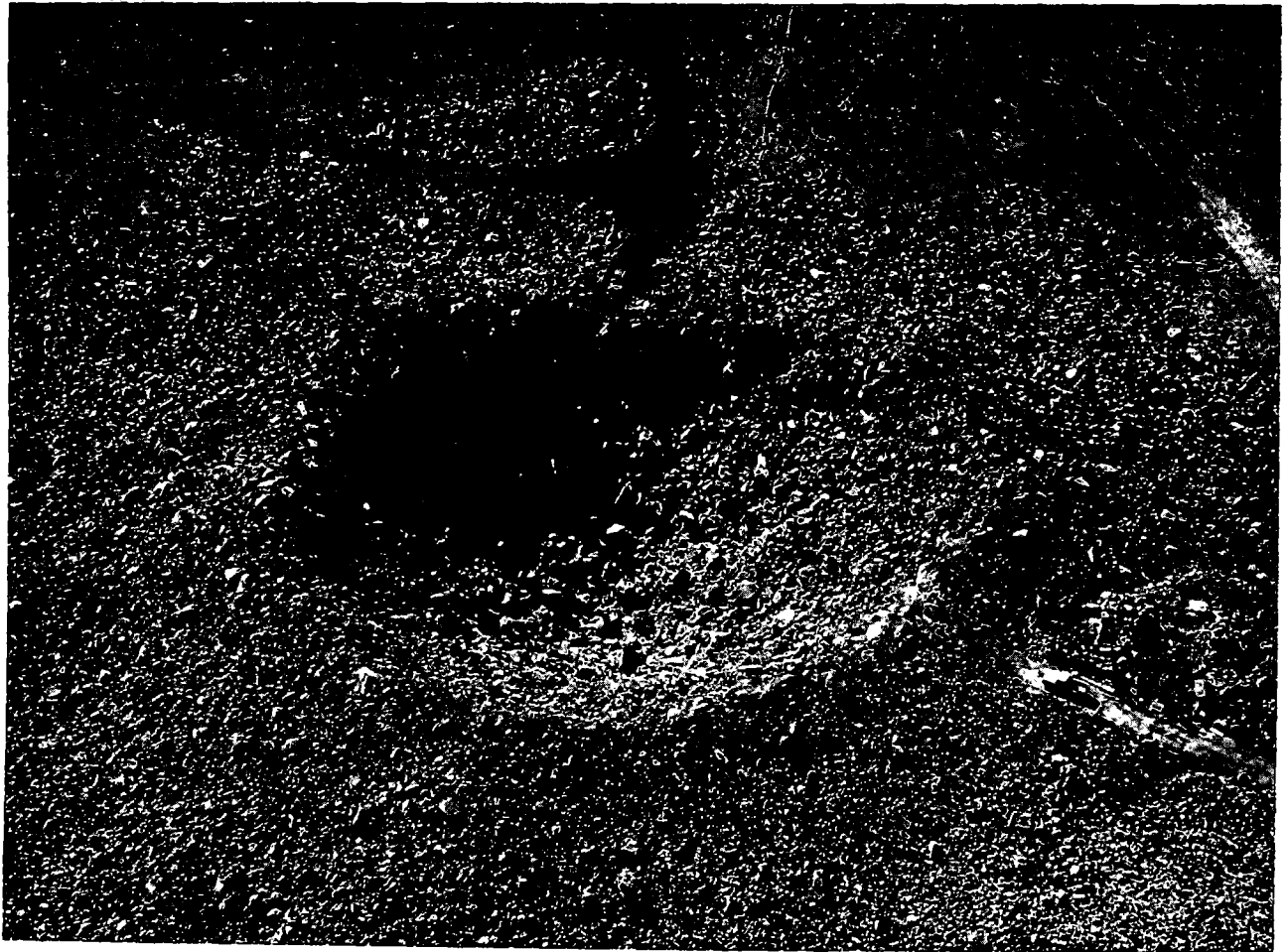


Figure 2-1. Typical nuclear crater.

2-18. Crater Definitions

a. Figure 6-1 shows a cross section of a typical nuclear crater depicting pertinent crater dimensions and zones of disturbance.

- (1) The *apparent crater* is defined as that portion of the visible crater

which is below the preshot ground elevation. The apparent crater is of primary interest when considering military engineering applications involving excavation operations or the creation of crater obstacles.

(2) The *true crater* is defined as the boundary (below preshot ground level) between the loose, broken fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The true crater dimensions are of primary interest to the engineer when considering applications involving the demolition of hard targets.

(3) The *lip* of the crater is composed of uplifted and deformed rock or soil with the upper portion of the lip consisting primarily of material which has been ejected and thrown out of the crater (*ejecta*).

b. The zones of disturbance resulting from a nuclear cratering detonation in soil or rock are identified as the rupture zone and plastic zone. The undisturbed region beyond the plastic zone is called the elastic zone. The following definitions characterize these various zones.

(1) The *rupture zone* is that zone extending from the true crater boundary in which the stresses created by the

detonation cause fracture and crushing of the material.

(2) The *plastic zone* is that portion of the cratered medium beyond the rupture zone in which the stresses created by the detonation cause permanent deformation but are not great enough to cause significant fracturing or crushing of the material. The transition from the rupture zone to the plastic zone is gradual. In the plastic zone small permanent displacements occur. These displacements decrease to infinitesimal values as the elastic zone is approached.

(3) The *elastic zone* is that zone extending beyond the plastic zone in which no permanent fissures, cracks, or displacement of material is evident.

c. *Subsidence Crater*. At very deep depths of burst in most soil media with the exception of hard rock, a crater results from the collapse of overlying material into the formed cavity. A crater created in this manner is referred to as a subsidence crater. Figure 2-2 shows a typical subsidence crater formed by a nuclear explosive detonated deep below the surface.



Figure 2-2. Typical subsidence crater.

2-19. Effects of Depth of Burst

a. Dimensions. The size and shape of the crater produced varies greatly with the depth of burial of the ADM. As the depth of burst increases, crater dimensions increase to a maximum at some optimum depth, then decrease until a depth of burst is reached where a subsidence crater may be formed. The relationships of depth of burial and crater formation are appropriate for most soil media. For a given energy yield, however, the maxi-

imum crater dimensions differ for various soils and occur at different depths of burst.

b. Optimum Depth of Burst. Optimum depth of burst is that which produces, under prevailing conditions, the most favorable combination of crater dimensions for accomplishing the purpose of the intended crater. Although depth of burst may be selected to maximize crater diameter, depth of crater is usually more significant in tactical operations when vehicular obstacles are desired.

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CHAPTER 3

COMMAND AND STAFF RESPONSIBILITIES IN ADM EMPLOYMENT

Section I. TACTICAL CONSIDERATIONS OF ADM

3-1. General

There are several important features of ADM that the commander may advantageously employ to support tactical operations. Since ADM are emplaced without delivery error, the most efficient use of nuclear energy is achieved. ADM can accomplish missions which might normally be prohibitive for conventional explosives primarily because of the logistical effort involved. The destruction of massive structures or missions that require moving large quantities of earth, such as blocking defiles or tunnels, are easily within the capability of ADM. The size of the munition makes the time, manpower, and logistical support infinitesimal compared to that re-

quired for conventional demolitions. Moreover, the yields of ADM in proportion to their weight and volume provide the capability for largescale demolitions with troop safety distances significantly reduced.

3-2. Offensive Operations

ADM are employed in the offense by the tactical commander as an economy of force measure to rapidly create obstacles which impede or deny enemy movement. ADM may be used to—

- a. Contribute to flank and rear security.
- b. Impede a counterattack (fig. 3-1).
- c. Assist in enemy entrapment (fig. 3-2).

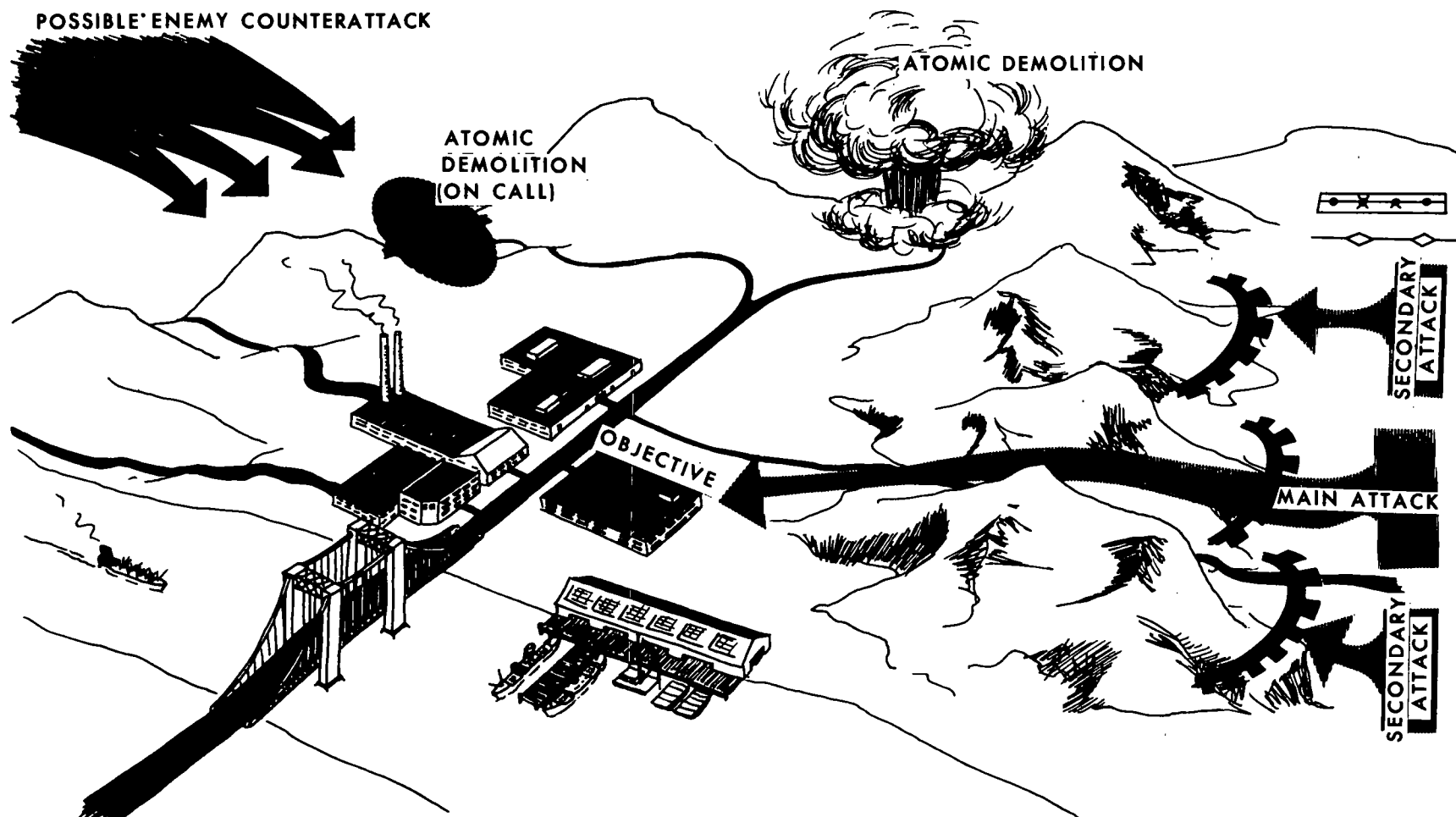


Figure 3-1. ADM to impede counterattack..

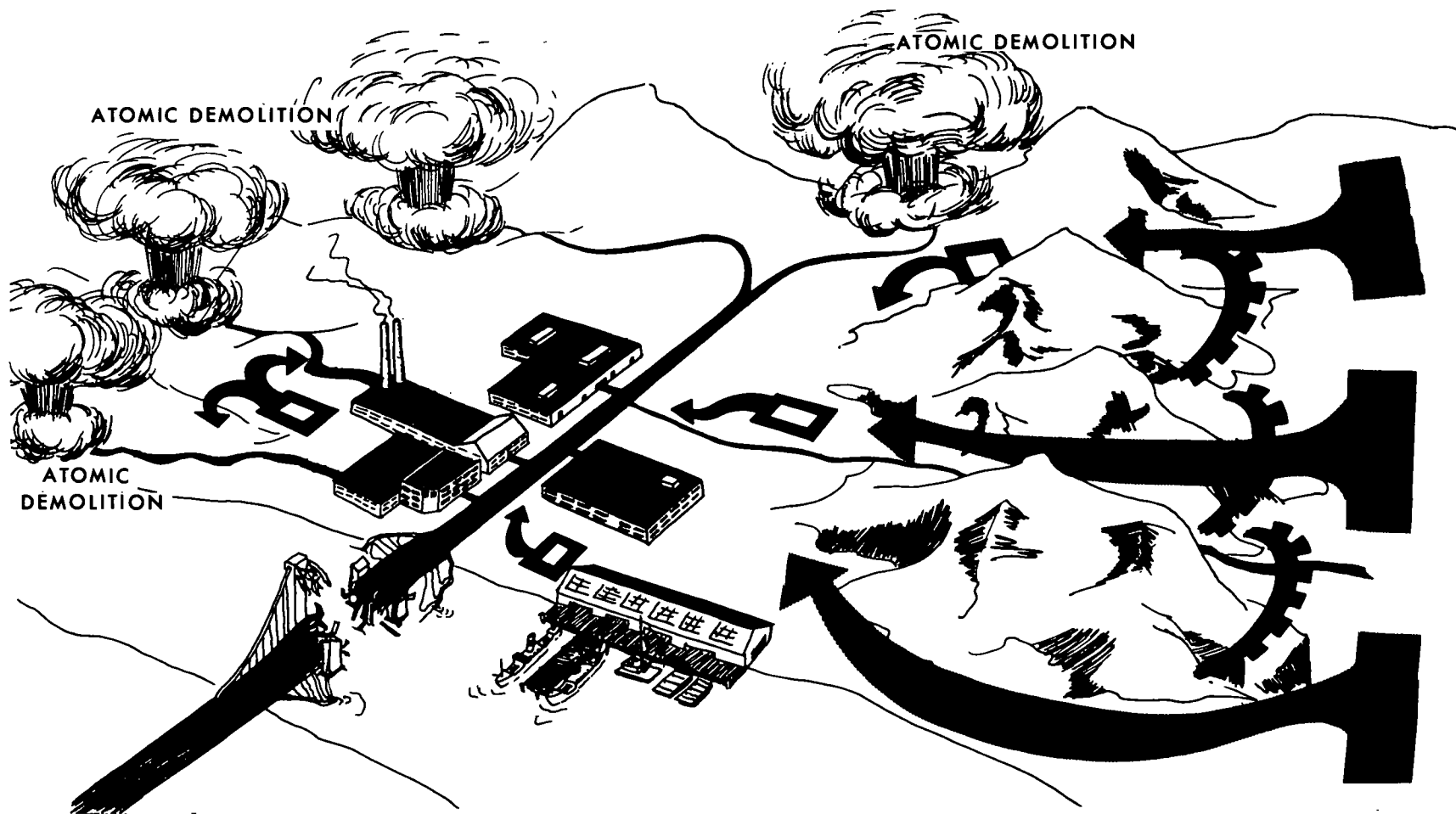


Figure 3-2. ADM to assist in enemy entrapment.

3-3. Defensive Operations

The obstacles produced by ADM are readily incorporated into defensive barrier systems. ADM, when employed individually, also increase the effectiveness of natural and man-made obstacles. In the defense when time, equipment, and manpower are critical, ADM may be employed to:—

- a. Block avenues of approach by cratering defiles or creating rubble.
- b. Sever routes of communication by destroying tunnels and bridges or cratering roads.
- c. Create areas of tree blowdown and forest fires.
- d. Crater areas including frozen lakes subject to landings by hostile airmobile units.
- e. Create water barriers by the destruction of dams and reservoirs.

3-4. Retrograde and Denial Operations

a. The mission of retrograde operations—the trading of space for time—is significantly assisted by the employment of ADM. Obstacles are extensively used, and the availability of nuclear yields in easily transported packages makes ADM well suited for incorporation into the operational plan.

b. Denial targets, such as dams, tunnels, airfields, ports, and canals, may be destroyed

or denied by ADM. Strategic denial targets are normally assigned through command channels to the lowest tactical commander who possesses the capability to accomplish the desired degree of denial. Under unusual circumstances, the theater or field army commander may retain such denial targets under his control.

3-5. Characteristics of ADM

a. *General.* In order to plan for the tactical employment of ADM, commanders and staffs must be familiar with their inherent design characteristics. Features which influence ADM employment and emplacement are: available yields, emplacement dimensions, transportation weight, firing options, sub-surface capabilities, and safe separation distance between ADM bursts.

b. *Hypothetical ADM Family.* Because of security considerations, data pertinent to actual stockpile ADM are not presented in this manual but are set forth in FM 101-31-2. In this manual, a hypothetical family of ADM is introduced to facilitate unclassified instruction in ADM employment. Damage and contingency effects tables for this hypothetical family of munitions are contained in appendix II whereas each ADM together with its yield, cannister length, minimum diameter of emplacement hole, and transportation weight is shown in table 3-1.

Table 3-1. Hypothetical ADM family

Model/yield (kt)		Cannister length		Emplacement hole diameter		Transportation weight (pounds)
		feet	meters	inches	meters	
SIERRA	/0.01	3	0.91	15	0.38	100
TANGO	/0.03	3	0.91	15	0.38	100
UNIFORM	/0.05	3	0.91	15	0.38	100
VICTOR	/0.10	3	0.91	15	0.38	100
WHISKEY	/0.30	3	0.91	15	0.38	100
ALFA	/0.50	5	1.52	30	0.76	500
BRAVO	/1	5	1.52	30	0.76	500
DELTA	/5	5	1.52	30	0.76	500
ECHO	/10	10	3.05	36	0.91	1500
GOLF	/50	10	3.05	36	0.91	1500
HOTEL	/100	10	3.05	36	0.91	1500

c. Firing Options. Once emplaced, each ADM of the hypothetical family is considered to have a remote, on-call firing capability as well as a timer option. When using timer option, the time of detonation may be varied in 10-minute increments from 10 minutes to 1 hour and in 30-minute increments to 12 hours. Accuracy of the timer is assumed to be ± 5 minutes per hour of time set on the timer (para 4-12).

d. Subsurface Capability. ADM of the hypothetical family are assumed to have both an underground and underwater capability. Underground burial is limited to 10 meters (33 ft) of backfill which is tamped material replaced directly on top with no protective shielding of the ADM. Underwater detonation is possible in depths up to 30 meters (100 ft). If greater depths are desired, special adaptive devices are required to protect the munition from excessive overhead pressure.

e. Separation Distance. To insure that one emplaced ADM is not damaged by the detonation of another in the same general target area, it is assumed for the hypothetical family that a separation distance of 1,000 meters (3,300 feet) between ADM detonations on the surface is required for all yields. For subsurface bursts near optimum depths, this distance may be reduced by one-half.

f. Residual Radiation. Residual radiation is an important consideration in the employment

of ADM. This aspect of ADM employment from a troop safety standpoint is discussed in chapter 7.

3-6. Response Time

In addition to the design characteristics of ADM, the time necessary to analyze the target, secure the emplacement site, deliver and prepare the ADM for firing, emplace the munition, and warn friendly units significantly affects the manner in which ADM are employed. As a basis for general tactical planning, 2 hours is assumed to be the average time for a reasonably well-trained ADM team operating in daylight under favorable conditions to prepare and emplace a hypothetical ADM with remote options on the surface or in a previously prepared position. If only timer option is used, planning time may be reduced to 1 hour. Blackout operations, enemy interference, elaborate emplacement techniques, or severe weather conditions may considerably extend this period. Moreover, transportation time to the emplacement site is in addition to the above-stated times. Obviously, each target presents varied circumstances which affect response time and require individual consideration prior to ADM employment. Nevertheless, response time may be materially reduced by thorough training and the establishment of effective ADM standing operating procedures (SOP).

Section II. COMMAND AND STAFF PROCEDURES

3-7. General

Planning for the employment of ADM involves the same command and staff procedures normal to planning any tactical operation. The command, intelligence, operational, and logistical procedures are carried out concurrently rather than sequentially. ADM missions are implemented by plans and orders formulated under the guidance of the tactical commander during staff planning.

3-8. Allocation of ADM

a. Because of the combat potential afforded by ADM and their limited number, the commander carefully controls the supply, expendi-

ture, and resupply of this type munition. ADM fall into the category of special ammunition, which is ammunition specially designated by the Department of the Army because of unique requirements in control, handling, and security.

★*b.* An allocation of ADM is the apportionment of a specific number of complete ADM to a commander during a specified period of time as a planning factor for use in the development of plans. Additional authority is required for actual dispersal of allocated ADM to locations desired by the commander to support his plans. A commander cannot authorize the expenditure of an ADM unless he has been specifically authorized to do so; or unless he is disposing of

the munition in compliance with emergency denial operating procedures. Procedures for disposition of excess ADM are found in FM 9-6.

c. The duration of the allocation periods generally is dictated by the commander's concept of the operation. He allocates ADM for the period during which he can visualize the operation. He retains ADM in reserve for those periods that he cannot visualize, i.e., for employment against targets of opportunity and for use during later phases of the allocation period. The duration of an allocation period differs at each echelon of command. The field army commander may be allocated ADM for a longer period than the corps commander and the corps commander for a longer period than the division commander.

d. Reserve maneuver forces receive only a planning allocation until committed; at this time, they may be assigned a portion of the reserve allocation.

e. A commander who allocates ADM to a subordinate command may withdraw or change that allocation as required. Reduction in an allocation is made only when absolutely essential and with as much prior notification as possible.

3-9. Command Guidance

a. The magnitude and nature of nuclear effects have a profound influence on ground operations. Therefore, command guidance to the staff before commencement of planning is essential. If there is little time for staff planning, this guidance may consist of an immediate decision by the commander to employ ADM. When more time is available, the guidance may include specific courses of action for staff consideration during the development of staff estimates.

b. In developing his initial staff planning guidance, the commander considers the requirements of all the general staff. In addition, he provides guidance for the staff engineer, the artillery commander, the chemical officer, and other concerned staff officers. The commander

provides additional guidance as required throughout all planning phases up until the time the ADM mission is executed.

c. It is essential that commanders and staff officers generally understand the capabilities and limitations of ADM, the combat service support requirements involved, and the procedures for employing these munitions. These officers receive technical advice from nuclear weapons employment officers (NWEO) and engineers on matters relating to the use of ADM.

d. Initial staff planning guidance normally falls into the following categories: type of targets, allocation to subordinate units, desired ADM reserve, and acceptable degree of risk for civilian populations in the area. The commander's initial staff planning guidance for ADM employment varies in content with the echelon of command. Damage criteria and troop safety considerations are matters of standing operating procedures (SOP). Command guidance in these respects is appropriate only when departure from SOP is desired. Based on the SOP, the nuclear weapons employment officer and engineer determine the extent and nature of the damage desired and recommend the ADM best suited for that task. Similarly, the commander designates, whenever possible, negligible risk for his own and adjacent forces. The staff, without further direction, takes this into account in their operational planning. If greater than negligible risk must be taken or if friendly troops must be warned, the nuclear weapons employment officer includes this information as part of his recommendations. Creation of obstacles to friendly movement and similar undesirable effects are also matters of SOP not normally requiring specific guidance to the staff and nuclear weapons employment officers.

3-10. Staff Responsibilities

a. In planning the employment of ADM, certain specific responsibilities are allocated to the general and special staff. Coordination

within the staff is continuous, and areas which tend to overlap are handled jointly or by specific command assignment.

b. The intelligence officer keeps the commander, subordinate units, and other staff sections abreast of potential ADM targets including their description and location. He also makes available timely information concerning weather, terrain, and significant enemy activities.

c. The operations officer has primary staff responsibility for the planning of ADM missions. He is responsible for the preparation of the atomic demolition plan, and he utilizes the advice and assistance of the engineer in carrying out this responsibility (para. 3-11). The operations officer:—

- (1) Integrates the use of ADM with the scheme of maneuver.
- (2) Disseminates warning information to appropriate higher, lower, and adjacent headquarters (para. 3-21).
- (3) Recommends the allocation of munitions to include the prescribed nuclear load and special ammunition stockage.
- (4) Evaluates potential ADM targets recommended by the intelligence officer and engineer.
- (5) Requests detailed analyses of selected targets from engineer and fire support elements and incorporates the results of these analyses into the courses of action under consideration.
- (6) Reviews and secures approval for the atomic demolition plan and ADM standing operating procedures (paras 3-13 and 3-14).
- (7) Assures integration of planned supporting fires with the atomic demolition plan when required.
- (8) Supervises the ADM surety program.

d. The logistics officer considers the supply and distribution capability of the unit and, based on this information, advises the commander, the operations officer, and the staff engineer on the logistical feasibility of each course of action under consideration. He has

primary staff responsibility for transportation, storage, maintenance, and distribution of ADM prior to their employment (para 3-22).

e. The artillery officer participates in ADM target evaluation in coordination with the operations officer and the engineer. If required, he incorporates the atomic demolition plan into the fire support plan.

f. The chemical officer advises the commander and staff on fallout prediction, radiological survey, monitoring, and decontamination.

g. The civil affairs officer estimates the effects of ADM on the civilian population and vital civilian facilities. He advises the commander and staff of any consequences which may adversely affect the accomplishments of the overall mission or constitute a violation of the commander's legal and moral responsibilities to the civilian population. He recommends warning or other ameliorating measures as appropriate.

h. The surgeon advises the commander and staff on radiation hazards and effects on personnel.

3-11. Engineer Staff Officer

a. The Army, corps, or division staff engineer participates in preliminary conferences in which methods of carrying out the commander's plan are discussed. Targets and delivery means are considered and the engineer, when appropriate, presents recommendations for retention or elimination of specific nuclear targets. The engineer is particularly concerned with the effects of nuclear employment on terrain, such as cratering, tree blowdown, and radiological contamination, and the influence of these effects on the overall tactical plan and engineering requirements. He may assist in the evaluation of likely targets and propose employment of atomic demolition munitions.

b. When the commander decides to employ atomic demolition munitions, the engineer recommends the executing unit to control the mission. Normally, the mission is assigned to the division responsible for the area in which

the demolition sites are located. The mission may be accomplished by the division within its own capability; however, if the number of demolition targets warrant, the engineer recommends attachment of additional ADM teams. If the demolition site is not in the division area, the engineer recommends the control arrangements appropriate to the circumstances and designates the emplacing and firing units. The executing unit may be a major tactical organization such as an armored cavalry regiment, a separate brigade, or an engineer combat group. In situations which require direct control of the demolition by the commander, the engineer may recommend the formation of a demolition task force and designate the engineer elements of the task force (FM 31-10). Unless the mission has been assigned to a unit which has an ADM capability, the engineer is also responsible for providing ADM teams and additional engineer support. The capability of the engineers to support multiple ADM operations is primarily dependent upon the number of available ADM teams. Specifically, the engineer staff officer has special staff responsibility for the employment of barriers and the erection and reduction of obstacles. Therefore, he is the officer who prepares the atomic demolition plan under the supervision of the operations officer and through whom all matters concerning ADM are coordinated.

c. Commanders of engineer combat units, operating closely with other combat elements to form combined arms teams, function in the capacity of staff engineer for the supported unit. Under these circumstances, the engineer commander advises on engineering aspects of ADM employment, selects suitable ADM targets, and recommends the task organization to conduct ADM missions. The engineer commander coordinates ADM employment with other staff members of the combat maneuver unit to which he is attached or in direct support and maintains close liaison with higher engineer echelons and ADM teams.

3-12. Estimate of the Situation

An estimate of the situation is a logical and orderly examination of all factors affecting

the accomplishment of the mission. As a result of the estimate, the commander decides the proper method of engaging each demolition target. Factors affecting the decision to employ ADM are included in the following discussion:

a. Target evaluation is the process of examining a target to determine its importance and to establish its priority. It encompasses an analysis of the tactical mission and an evaluation of target intelligence to include terrain and meteorological conditions.

b. Once targets have been evaluated and given a priority for destruction or denial, the commander compares the advantages of employing ADM to those of conventional demolitions.

c. There are many considerations which influence the decision to employ ADM against a target. *For example:*

- (1) The availability of ADM is included in the estimate.
- (2) The time available to employ ADM influences the decision.
- (3) The ability of the enemy to interfere with ADM missions is also evaluated.
- (4) The results of target analysis affect the estimate of the situation.

d. Before target demolition, circumstances may alter the commander's decision and cause modification or cancellation of a specific ADM mission. Such circumstances include adverse meteorological conditions, malfunction of the ADM, or an enemy threat to capture or destroy the munition. As a result, one or more of the following actions, which may necessitate return to the emplacement site, may be required: a change in detonation times, repair, recovery, or denial of the munition. It is, therefore, important that the commander be continually informed about changes in the tactical situation affecting ADM targets.

3-13. Atomic Demolition Plan

a. The atomic demolition plan represents the commander's decision for the selective employment of ADM. The operations officer has general responsibility for the atomic demoli-

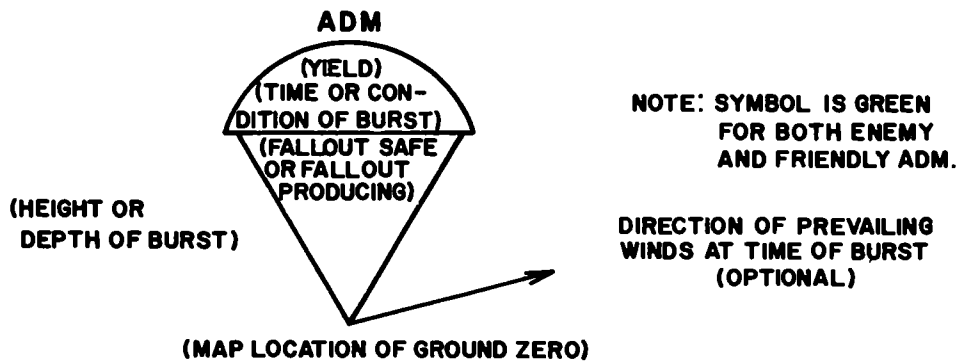
tion plan in close coordination with the staff engineer and fire support element. When approved by the commander, the atomic demolition plan may be announced verbally; transmitted electrically; or published as an appendix to the barrier plan annex, an appendix to the engineer annex, or an appendix to the fire support annex. When published as an appendix to the barrier plan annex, the atomic demolition plan need only be referenced in the engineer and fire support annexes. The atomic demolition plan contains the information necessary for subordinate units to prepare their supporting plans (app IV).

b. The atomic demolition plan normally is prepared in detail for preplanned targets only. An atomic demolition plan contains as a minimum—

- (1) Target locations and descriptions.

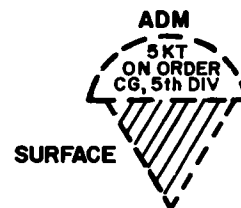
- ★ (2) Target designation number or code word.
- ★ (3) Model and yield of ADM, locations of ground zero, emplacement configurations, and depths of burst.
- (4) Units to be designated task responsibility for each ADM mission.
- (5) Firing options.
- (6) Times of emplacement and final arming, if applicable.
- (7) Times or conditions for execution of each target, if applicable.
- (8) Authority to arm and fire each ADM.
- (9) Authority to change or cancel each mission or to institute emergency ADM evacuation or destruction.

c. The atomic demolition plan may be partially prepared and transmitted in overlay form utilizing conventional ADM map symbols illustrated in figure 3-3.

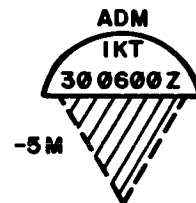


DESCRIPTION

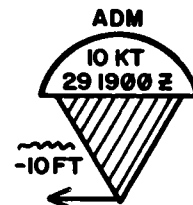
1. Proposed surface burst ADM (dotted lines), 5 KT, fallout producing (shaded stem), to be detonated on order of the Commanding General, 5th Division.



2. Emplaced but not detonated ADM (dotted stem), 1 KT, minus 5 meters underground, fallout producing, to be executed on the 30th of the month at 0600Z hours.



3. Executed ADM (solid lines), 10 KT, minus 10 feet underwater (below wave line), fallout producing, easterly prevailing wind, detonated on the 29th of the month at 1900Z hours.



4. Executed enemy ADM (double head), approximately 0.5 KT (brackets), fallout safe (no shading in stem), minus 200 meters underground, detonated on the 28th of the month at 1400Z hours.

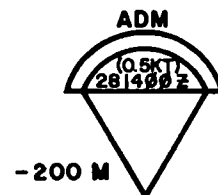


Figure 3-3. ADM conventional map symbols.

3-14. ADM Standing Operating Procedures (SOP)

a. To insure effective ADM employment, combat maneuver battalions and above prepare a portion of the unit SOP for implementation upon assignment of an ADM mission. In general, items to be standardized as matters of SOP include task organization for ADM missions, staff coordination and responsibilities, transportation, communications, command and control, safety, security procedures, and unit training. Each unit SOP is closely coordinated with the ADM procedures of

higher headquarters and supporting engineers.

b. Engineer combat units maintain a detailed ADM SOP at the group, battalion, and company level. This SOP incorporates existing directives, circulars, memorandums, bulletins, and SOP items of higher command echelons and standardizes ADM operations within the unit and in its coordination with supporting and supported units. Appendix IV contains a guide for the preparation of an engineer battalion ADM SOP.

Section III. CONDUCT OF ADM MISSIONS

3-15. Types of ADM Targets

Selection of ADM targets are usually based on intelligence reports and engineer demolition reconnaissance (paras 4-5 and 4-6). The tactical commander considers the recommendations of his staff, especially the engineer and NWEQ, before authorizing the employment of ADM or requesting support from the ADM allocation of a higher echelon. In accordance with the tactical situation, ADM targets are categorized in two types:

a. *Targets of opportunity* are unscheduled targets located during the course of tactical operations and whose success often rests on the speed of execution. Targets of this nature are more prevalent during fluid tactical operations, and their acquisition is often made at lower echelons of command with no specific ADM allocation (para 3-16).

b. *Preplanned targets* are targets which have previously been evaluated and scheduled and whose execution is based on some contingency of the operational plan or enemy. In many instances, emplacement positions have been prepared, targets assigned a priority of execution, subordinate units alerted of their respective roles, and written orders prepared to facilitate rapid implementation (para 3-17).

3-16. Targets of Opportunity

a. The destructive nature of ADM necessitates strict command and control as well as close coordination between engineer, fire control, and CBR staff agencies. For targets of opportunity, a commander requiring ADM support for which he has no allocation requests support from the next higher command (fig. 3-4). Simultaneously and through separate channels of communications, engineer, fire support, and CBR elements of concerned headquarters are alerted. ADM requests contain detailed tactical justification to permit evaluation and analysis of the mission. As a minimum, a request for ADM support contains the target description and location, the results desired, and the desired time of burst. The request may contain additional information such as limiting requirements, acceptable risk to friendly troops, or location and degree of protection of nearest friendly troops and civilians. If the target has been analyzed by the requesting unit, the request may specify the desired ADM and yield. (See sample ADM request format, app. IV.)

b. The commander, who has an ADM allocation and in whose area significant nuclear effects will be contained, approves or disapproves the request. In some cases, he may sub-

mit a request to higher echelons for ADM more suitable for the target than those among his own allocation.

c. Early notification to ADM emplacement, security, and transportation units reduces delays in target execution. Advance information (warning orders) which provides time to pick up and prepare the munition for firing is desirable. Occasionally, this information is

given to ADM emplacement units prior to the time a decision is made to actually implement the mission.

d. Upon approval or disapproval of an ADM request, the requesting unit is notified. A commander who disapproves a request provides the reason for the disapproval, whenever possible.

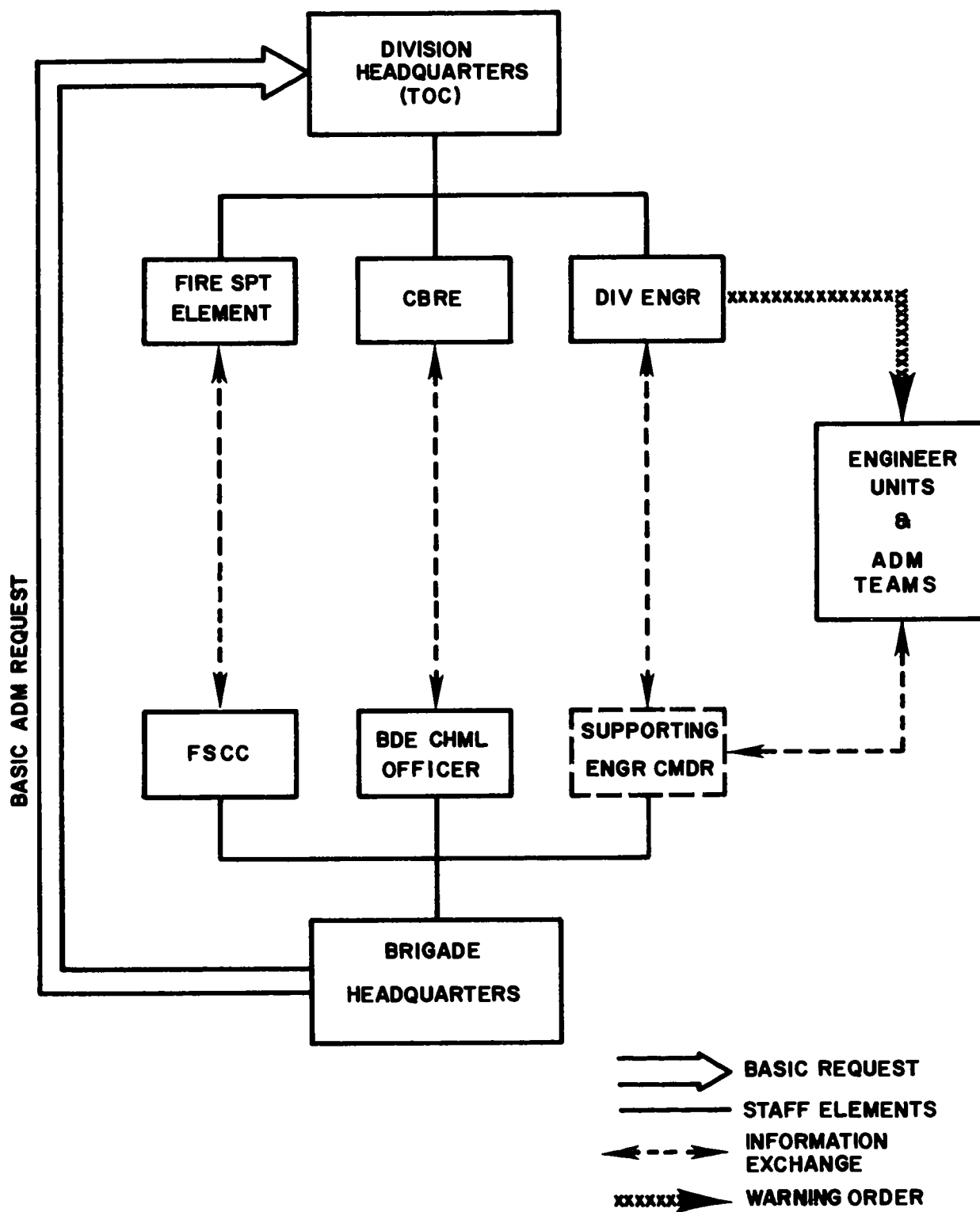


Figure 3-4. Typical ADM requests from brigade to division.

3-17. Preplanned Targets

Normally, preplanned, *tactical demolition targets* are planned and executed on order of corps and lower commanders. *Strategic* demolitions, on the other hand, may be planned and executed on order of field army or higher command echelons. If a demolition target has both strategic and tactical implications, preparation and execution of the target is usually delegated to the tactical commander responsible for the area in which the target is located. Some targets may be so important to the success of the operation, however, that the commander authorizing ADM employment may retain target execution for his own order. Such demolition targets are termed *reserved demolitions* (FM 31-10) and may include targets planned as part of preliminary operations as well as those to be destroyed in the face of an advancing enemy. For reserved demolitions, the commander in control of target execution establishes direct communications with the commanders concerned or dispatches a liaison agent or staff officer to the target site to receive and transmit the execution order. Under such circumstances, the liaison agent insures that destruction is accomplished at the proper time through coordination with responsible commanders in the target area. Regardless of the method of execution, at least three commanders are normally concerned with the execution of preplanned demolitions—

a. *The releasing commander* (authorized commander) has overall responsibility for the mission, authorizes the ADM to be employed from his own nuclear allocation or requests an additional allocation from higher command echelons, and orders or delegates target execution. The releasing commander may utilize his own headquarters or designate a subordinate *executing unit* to conduct the ADM mission (para 3-18).

b. *The demolition guard commander* is normally a subordinate of the executing unit commander and is held responsible for his assigned ADM target and the local security thereof (para 3-19).

c. *The demolition firing party commander* is the senior engineer of the ADM firing party attached to the demolition guard for the mission (para 3-20).

3-18. Releasing Commander

☆a. The releasing commander normally is the commander of a division or larger formation. He is appointed by higher headquarters and is empowered to authorize ADM expenditure subject to the restraints imposed by higher authority. The releasing commander exercises approval authority over all subordinate ADM plans and targets within his operational area. He designates his own headquarters or a subordinate unit as the executing headquarters for each ADM mission. A combat maneuver brigade, a task force, or any other major unit tactically responsible for the target area may act as an executing unit. In areas not under the control of a subordinate tactical commander, the releasing commander may designate an engineer group or battalion commander as the executing commander.

b. The releasing commander provides the executing unit with the resources needed to accomplish the mission. He provides instructions, as required, to coordinate all elements engaged in the mission and insures that adequate control procedures are initiated. If authority to detonate the ADM is retained by the releasing commander, reliable channels of communication must be established whereby the order to detonate the ADM may be quickly and securely transmitted.

c. The executing commander is responsible for ADM targets within his operational area and the execution of such targets in accordance with the orders of the releasing commander. The executing commander informs the releasing commander of any ADM mission beyond his capability and, if appropriate, recommends alternate courses of action. Details of the mission not specified by the releasing commander, such as fire support coordination, are the responsibility of the executing unit. The executing commander usually designates the formation (the demolition

guard) to provide local security for the mission and prepares the orders to the demolition guard commander and the commander of the demolition firing party (STANAG 2017, app IV). Communications are provided to insure adequate control of the mission; in addition, the executing commander may appoint a liaison agent as his representative to supervise target execution. The executing unit has the added responsibility of warning friendly units and civilians in the target area. Such responsibility encompasses control of traffic and refugee flow; and, if warranted, military and civilian evacuation of danger areas (FM 19-25). Lastly, the executing commander provides the releasing commander with changes in the state of ADM readiness, munition expenditures, and tactical damage evaluation reports.

3-19. Demolition Guard Commander

★ *a.* Upon designation as demolition guard by the executing unit commander and attachment of an ADM capability, the demolition guard commander is responsible to the executing commander for the direction and control of the ADM mission as provided by competent mission orders and for providing local security for the ADM. The composition and size of the demolition guard varies in accordance with the tactical situation.

b. In most cases, the demolition guard requires engineer support to accomplish the ADM mission. At the very minimum for hasty demolition, such assistance is composed of an engineer ADM firing party. For more deliberate demolitions, additional engineers and equipment to assist in emplacement are necessary. The means for actually detonating the ADM (i.e., the ADM firing party) are attached to the demolition guard for the duration of the mission. Attachment facilitates command and control and insures that clear-cut command lines for detonation of the ADM are established. Other engineers engaged in support of the mission, such as emplacement site preparation, need not be attached; they perform their tasks in direct support of the demo-

lition guard, provided adequate coordination of effort is maintained.

c. The demolition guard commander relays the orders of the executing headquarters to the demolition firing party commander. One order, referred to as the ADM firing order, is prepared by the executing unit in conjunction with the orders to the demolition guard for each target and contains necessary instructions for target demolition. Whenever possible, a written ADM demolition order follows a format which parallels, although it does not duplicate, the conventional demolition firing order standardized by STANAG 2017 (app IV).

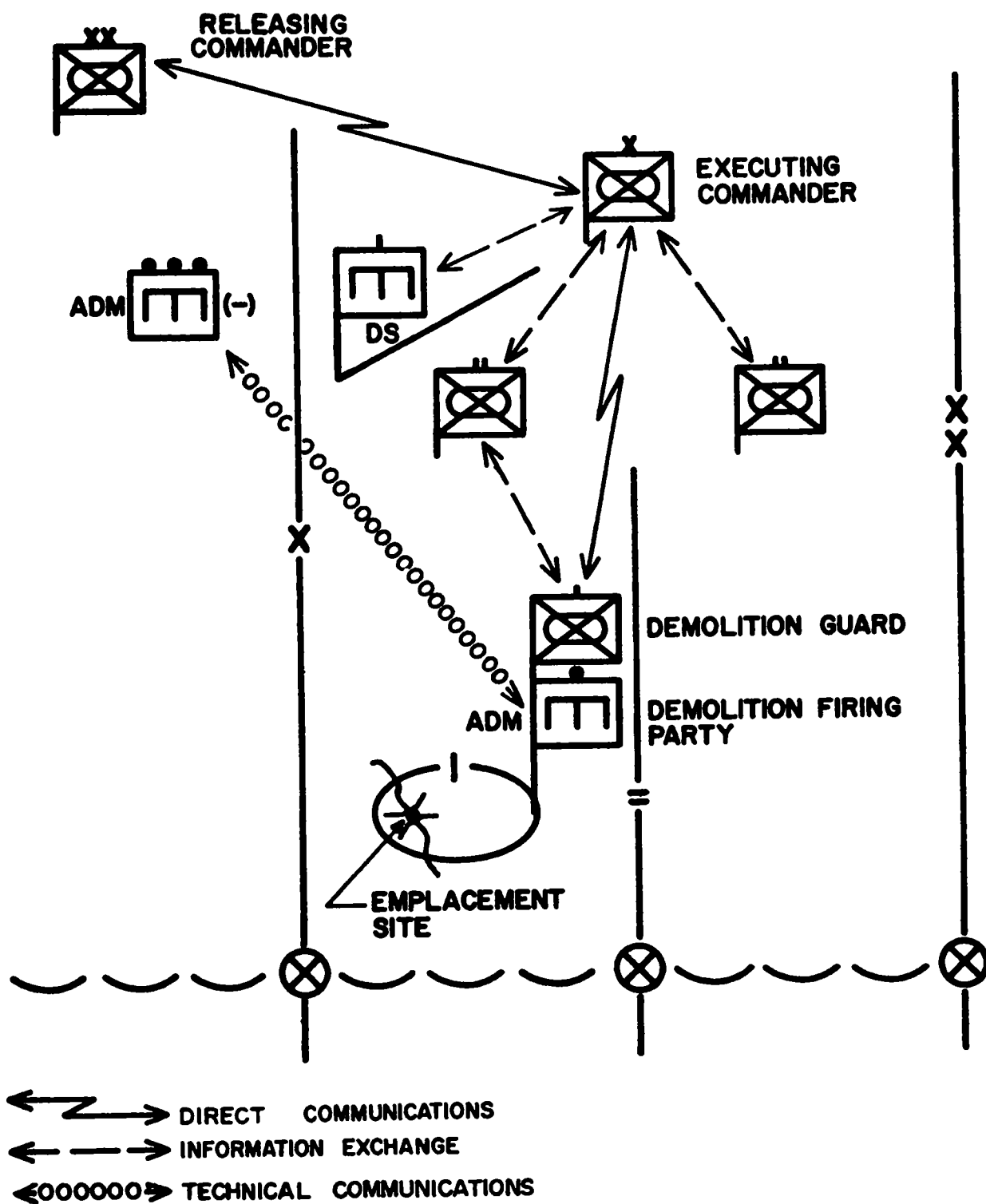
d. After the munition is armed, the demolition guard commander or his representative and the demolition firing party commander remain at the command site. Depending on the urgency of the target, the order for target demolition may follow normal command channels or may be established directly with the releasing commander and/or the executing headquarters (fig. 3-5). If such communications are established, the demolition guard assumes the role of a separate demolition task force.

e. The demolition guard commander is responsible for the local security of the emplacement and command sites and the evacuation of the demolition guard and firing party prior to detonation. Upon occupation of the area, outposts are established to provide all-around security; and observation and listening posts are organized to give early warning of an enemy advance. Liaison is accomplished with adjacent units, and the security of the ADM emplacement and command sites is coordinated with existing defenses in the area. The demolition guard insures that the routes of evacuation and areas designated to provide protection from the effects of ADM are disseminated to all members of the demolition guard, demolition firing party, and friendly units through which withdrawal is contemplated.

f. Lastly, the demolition guard commander is responsible for keeping the executing head-

quarters informed of the tactical situation at the target site and the state of readiness of the ADM. After detonation, a tactical damage evaluation report is rendered based on target damage reported by the demolition guard

commander. In the event of a misfire or partial destruction of the target, the demolition guard commander immediately initiates steps to complete target destruction by other means within his capabilities.



★Figure 3-5. Communications for a typical ADM target.

★3-20. Demolition Firing Party Commander

a. The demolition firing party is the element responsible for the technical aspects of the ADM mission. Its members are drawn from the appropriate engineer ADM unit (para 4-13-4-15).

b. The demolition firing party commander normally will be an engineer ADM squad leader. He is directly responsible to the demoli-

tion guard commander for the proper execution of the mission in accordance with the Atomic Demolition Munition Firing Order (DA Form 3065-R) (app IV). In addition, he furnishes the demolition guard commander with technical advice on transportation requirements, prefire test procedures, firing procedures, safing procedures, factors affecting reliability of the munition, emergency denial, and technical requirements for the emplacement site and command site.

Section IV. WARNING, LOGISTICAL, SECURITY, AND SAFETY PROCEDURES

★3-21. Warning of Friendly ADM Detonations

a. Advance warning of ADM detonations is required to insure that friendly forces and civilians are not subjected to casualty-producing nuclear effects. When an ADM is pre-planned, usually there is adequate time to alert personnel in areas where significant effects may be received. On the other hand, when ADM are employed against targets of opportunity, a standing operating procedure is required which permits rapid notification of personnel who could be affected by the detonation. The difficulty of warning of all personnel can be appreciated if the various concurrent activities in the combat zone are visualized. Messengers, wire crews, litterbearers, aid men, and engineer work parties move about frequently in the performance of their duties and often are not in the immediate vicinity of troop units when warning of impending nuclear employment is issued. Effects that are completely tolerable to troops in tanks or foxholes can cause considerable casualties among those in the open in the same area.

(1) Notification concerning friendly nuclear employment is a time-consuming process unless procedures are carefully established and rehearsed. On the other hand, dissemination of warning earlier than necessary may permit the enemy to learn of the operational plan.

(2) When there is insufficient time to warn personnel within the limits of visibility, only those who may receive tactically significant nuclear effects are warned. Warning of

units not requiring the information may cause them to assume a protective posture that interferes with the accomplishment of their mission. Generally, there is no requirement to warn subordinate units when target analysis indicates that there is no more than a negligible risk to unwarned, exposed troops. Dazzle to ground troops need only be considered in night operations.

(3) Aircraft, particularly Army aircraft, can be damaged by low blast overpressures. Likewise, dazzle is more significant to personnel operating aircraft than to personnel on the ground. Because aircraft can move rapidly from an area of negligible risk to an area where damaging nuclear effects or dazzle may be encountered, all aircraft within the area of operations are given advance warning during both day and night operations.

(a) Army aircraft are warned through the appropriate air traffic control facility or through the unit command net.

(b) Navy and Air Force aircraft are warned through Navy and Air Force channels. At corps and division level, the notification of planned nuclear employment is transmitted to other services through the Navy or Air Force liaison officer; at field army level, this notification is accomplished through the tactical air control center (TACC).

(c) Warnings to aircraft in Marine Corps operating areas will be initiated by the fire support coordination center (FSCC) which passes the warning to the Tactical Air Commander usually via the TACC and/or the direct

air support center (DASC) and/or the supporting arms coordination center (SACC).

(4) When employing very low yield nuclear detonations against targets of opportunity, some relaxation of the requirement for positive warning may be authorized.

b. Nuclear employment warning messages are disseminated as rapidly as possible. The requirement for speed is frequently in conflict with a requirement for communication security. Authentication procedures and encoding instructions for nuclear strike warning messages are included in unit signal operation instructions (SOI).

(1) The amount of information to be encoded is held to a minimum to expedite dissemination.

(2) Message items DELTA and FOX-TROT (app VIII) will not be sent in the clear unless insufficient time remains for the enemy to react.

c. Nuclear warning messages are given a precedence of FLASH.

d. The zones of warning, protection requirements for personnel located in any of the warning zones, and the content of a nuclear warning message (STRIKWARN) are prescribed by STANAG 2104 which is reproduced in appendix VIII.

e. All available communication means are used to rapidly disseminate nuclear warnings.

f. A fragmentary warning order may be issued while an ADM mission is being processed to alert units that are in an area where they may receive nuclear effects.

g. Procedure for friendly nuclear detonation warning.

(1) Warning responsibilities.

(a) Responsibility for issuing the initial warning rests with the executing commander.

(b) Commanders authorized to release nuclear detonations will insure that detonations affecting the safety of adjacent and other commands are coordinated with those commands in sufficient time to permit dissemination of warning to friendly personnel and the taking of protective measures. Conflicts must be submitted to the next higher commander for decision.

(2) The commander responsible for issuing the warning should inform—

(a) The requesting commander.

(b) Subordinate headquarters whose units are likely to be affected by the detonation.

(c) Adjacent headquarters whose units are likely to be affected by the detonation.

(d) His next higher headquarters, when units not under the releasing commander are likely to be affected by the detonation.

(3) Each headquarters receiving a nuclear warning message will warn subordinate elements of the safety measures they should take in light of their proximity to the desired ground zero.

(4) Unit SOP should require that STRIKWARN messages be acknowledged and there should be common understanding as to the meaning of the acknowledgment; e.g., all platoon-size units in the affected area have been warned.

3-22. Distribution of Atomic Demolition Munitions

a. Commanders and staff officers continuously evaluate the capabilities and limitations of logistical systems to support nuclear employment. Because of the destructive nature and limited availability of nuclear munitions, distribution is an operational as well as a logistical problem.

b. The nuclear munition logistical system is designed to operate in different tactical situations, forms of warfare, and operational environments. Commanders and staff officers concerned with planning and controlling special ammunition support activities consider the following requirements:

(1) Continuous nuclear logistical support of tactical operations.

(2) Simplicity and uniformity in procedures.

(3) Minimum handling of nuclear ammunition.

(4) Security of classified or critical material and installations.

★c. The specific quantity of special ammunition to be carried by a delivery unit is termed the prescribed nuclear load (PNL). The spe-

cific quantity of various special ammunition items to be stocked in an ordnance unit or installation is termed prescribed nuclear stockage (PNS).

★*d.* A commander controls the distribution of ADM by—

(1) Determining the number of ADM which organic or attached units under his control will carry as part of their special ammunition load (SAL).

(2) Designating any ADM from his own allocation or the allocation of a higher commander which he desires to have carried in the SAL of a unit that is under the control of a subordinate commander. This SAL may contain ADM to support the allocation of the subordinate commander as well as those to be delivered to support the allocation of the higher or adjacent echelon.

(3) Coordinating the stockage of ADM as part of the special ammunition stockage (SAS) of a special ammunition installation not under his control; directing the ADM stockage in special ammunition installations under his control.

e. The positioning of ADM for security and operational purposes may result in a commander having more ADM carried by his emplacement units than he is authorized to fire. He may also have fewer ADM within his command than he has been allocated. In the latter case, procedures are established by which the additional ADM can be quickly obtained when required.

f. When the availability of ADM permits, consideration is given to placing them in all engineer emplacement units. ADM may be so dispersed before allocations are announced. In some cases, this procedure permits greater responsiveness once unit allocations are announced.

g. Replenishment of SAL and SAS is accom-

plished by directed issue, automatic issue, or a combination of both. Because of the limited supply and the movement of ADM to meet the changing tactical situation, directed issue is most practical. If a relatively large number of ADM of a specific type and yield is available, a commander may direct that engineer units under his control replenish their SAL automatically as expenditures occur. The method of replenishment should be covered in the SOP.

h. Distribution of ADM is affected by—

- (1) Mission.
- (2) Currently released munitions and authorizations to fire.
- (3) Allocation, current and anticipated.
- (4) Munition availability.
- (5) Carrying capacity of emplacement units.
- (6) Security.
- (7) Transportation capability of support units.

i. Nuclear munitions are stored and issued to ADM teams by special ammunition units. Issues are made using supply point distribution procedures. The details of ammunition service are contained in FM 9-6.

3-23. Tactical Accountability

The decisive character of nuclear weapons and their limited availability make detailed accounting necessary. Information pertaining to ADM location, availability, authorization to fire, and expenditure is made available to the members of the TOC, the artillery fire direction center, and the staff engineer. In addition, the TOC and the engineer need information on ADM readiness status, operational capabilities of engineer emplacement units, and the travel time between logistical and tactical locations. This information is maintained in a manner to permit ready display to the commander and staff officer. Suggested forms or methods by

which needed information can be kept at various staff agencies are discussed in FM 101-31-1.

3-24. Security

a. Security is concerned both with safeguarding classified defense information and material from unauthorized disclosure as well as protection of the ADM and ADM firing party from enemy interference. Three types of active security measures are generally associated with an ADM mission (fig. 3-6):

- (1) *Physical security of the ADM and related defense information and material* is that protection afforded to deny physical, audible, and visual access by unauthorized personnel to ADM and associated equipment. Only authorized personnel (normally, only ADM team members and ordnance personnel) are permitted physical access to ADM. Responsibility for physical ADM security commences for the tactical commander with ADM pickup and continues until detonation; such security measures as transporting the munition in closed containers and erecting camouflage nets over emplacement sites are typical precautionary measures. This type of security is further related to national policy regarding disclosure of classified atomic defense information (Restricted Data). At the time of pickup, an *exclusion area* in the immediate vicinity of the munition is established and maintained throughout transportation, emplacement, and until detonation. Only authorized ADM personnel are permitted within the exclusion area although security forces of the escort guard or demolition guard may be called upon to assist in security enforcement immediately outside the exclusion area. Exclusion areas are clearly marked, when appropriate, by expedient means such as concertina wire or designated within the confines of a covered vehicle or struc-

ture. FM 19-30 contains recommended physical security techniques.

- (2) *Local security* provides immediate protection of the ADM and ADM team from enemy interference or sabotage during transport and emplacement. A *restricted area* around the munition is established which extends outward from the exclusion area. The size of the restricted area varies in accordance with the tactical situation and the size of the assigned escort or demolition guard. It is the area in which security forces are located or will deploy in the event of a halt during transport (see FM 19-25). The restricted area may be reinforced by the installation of protective minefields, warning devices, and obstacles. Such protective devices are carefully noted, however, in the event that return to the emplacement site becomes necessary. Personnel other than those designated by the demolition guard commander are not allowed access into the restricted area.
- (3) *Tactical security* encompasses those measures which are beyond the capability of the demolition guard; this type of security is generally provided by the tactical disposition of the executing unit. Tactical security may be provided by offensive and delaying action as well as defensive operations. Ideally, observed enemy ground fire should be excluded from the emplacement site. The executing unit is also responsible for maintaining open routes of withdrawal for the demolition guard and firing party. Although the requirement for tactical security in rear areas may be less severe than in forward areas, adequate provisions must be made for countering an attack by enemy guerrillas and infiltrators as well as airmobile units.

b. Passive security measures such as cover,

concealment, camouflage, decoy emplacements, and surreptitious infiltration (either ground, water, or air) to the emplacement site also contribute to the security of ADM missions.

c. Once the ADM has been armed and the demolition guard and firing party withdrawn, security of the site until detonation is still maintained by the executing unit. Ground and aerial surveillance and long-range direct and indirect fires (e.g., tank and artillery)

are possible methods of maintaining security once the emplacement site is evacuated.

d. The critical mission of ADM teams makes them a prime target for enemy attack. These teams are normally so small and so armed that they are only capable of self defense and protection of the munition and associated materiel. Tactical commanders must be prepared to augment these teams with well trained security forces to safeguard pickup, delivery, emplacement, and target execution.

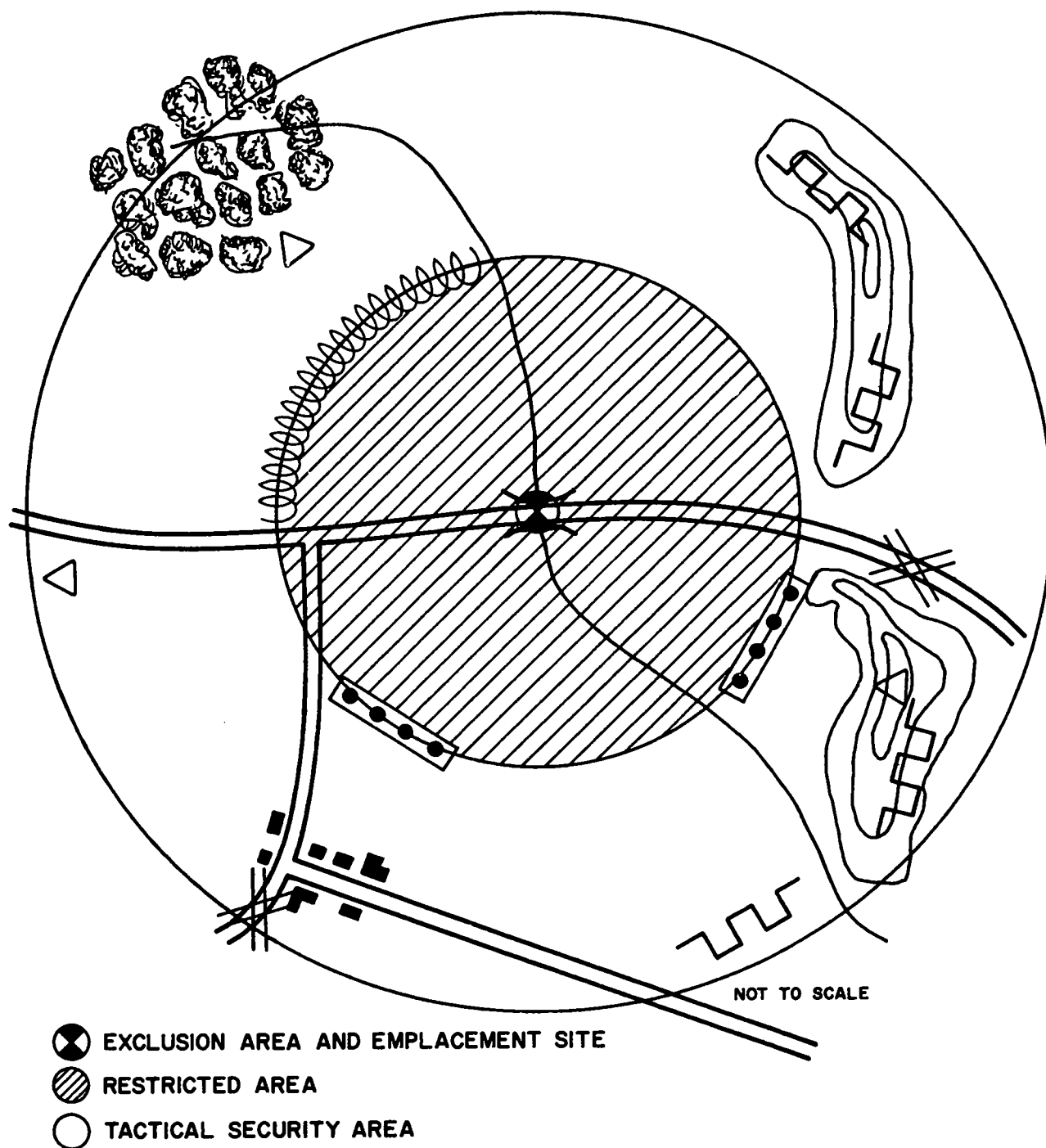


Figure 3-8. Security of an ADM emplacement site.

3-25. Safety

a. Safety is a continuing function of command. ADM, like other demolition materials, involve potential danger. The safety of troops and other personnel is of primary importance. Safety rules are mandatory for peacetime operations during operational readiness maneuvers, exercises, and training; no deviation is authorized. Safety rules are promulgated by Department of the Army letters and disseminated through appropriate command directives. Their purpose is to incorporate the maximum safety consistent with operational requirements.

★ b. If there is an accident involving ADM, the commander having possession of the munition at the time of the accident is responsible for notifying emergency teams to assist in

rescue, recovery, and damage assessment. Explosive ordnance disposal (EOD) units of the ammunition service structure should be called upon to render safe, recover, and dispose of unexploded munitions or, in the event of a low-order detonation, to recover and dispose of classified components and radioactive materials. FM 3-15 provides guidance for nuclear accident or incident radiological contamination control. ADM team safety activities are stated in the technical manuals for each munition, in associated safety publications, and in the unit SOP.

c. Temporary storage safety is governed in general by the quantity safe distance criteria which govern the temporary storage of high explosive and nuclear materials. Particular storage requirements for each demolition are covered in the prefire manual for that munition.

CHAPTER 4

COMBAT ENGINEER UNITS

Section I. ENGINEER STAFF RESPONSIBILITIES

4-1. General

The field army, corps, and division engineer staff officers rely heavily on their staffs in the preparation, planning, and conduct of ADM missions. Normally, the staff engineer delegates to members of his unit staff responsibility in the preparation, planning, and conduct of ADM missions. Key personnel of engineer brigades, combat groups, and combat battalions charged with primary staff responsibility in ADM operations are the intelligence officer (S2), the operations officer (S3), and the supply officer (S4). Other staff officers such as the assistant division engineer, adjutant (S1), reconnaissance officer, liaison officer, and communications officer perform duties in ADM operations as specifically directed by the unit commander or as outlined in the unit SOP. Moreover, each subordinate engineer commander assumes an engineer staff role when in direct support of or attached to a combat maneuver element and is, in such circumstances, also responsible for advising the supported commander in engineering aspects of ADM employment.

4-2. Intelligence Officer (S2)

Responsibilities normally assigned to the engineer S2 in ADM employment include—

- a. The collection and evaluation of potential ADM targets to include structural, geologic, and cultural characteristics (para 4-5 and 4-6).
- b. Terrain and weather analyses pertinent to ADM targeting.
- c. Ground and aerial reconnaissance of selected ADM targets (para 4-6).
- d. The collection from artillery and hydrologic (TOE 5-500) elements of meteorological data for use in target analysis.
- e. The processing and dissemination of ADM reconnaissance.
- f. The maintenance of a current ADM reference file and ADM mission target analysis evaluation folders.
- g. Security measures applicable to ADM storage, movement, and emplacement in coordination with the S3, S4, and supported and supporting units.
- h. The supervision of administrative personnel procedures to insure that only those authorized by current Army regulations are granted access to ADM defense information.

4-3. Operations Officer (S3)

The engineer operations officer has the primary staff responsibility for ADM employment. Specifically, his responsibilities include—

- a. Preparation of the unit ADM SOP and technical advice for and coordination of the ADM SOP of supported and subordinate units. (See format, app IV.)
- b. Maintenance of unit ADM training records.
- c. Supervision of the unit ADM training program (para 4-7).
- d. Direction of detailed target evaluation of selected ADM targets based on command guidance, the unit SOP, staff recommendations, and the requests of supported units.
- e. Recommendations as to the requirements for ADM teams and other engineer support required for specific targets.
- f. Fallout and surface water contamination prediction from friendly ADM employment in

coordination with S2 and appropriate CBR element.

g. Coordination of matters relating to ADM operations with other staff members; subordinate units, and supported units to include points and times of ADM pickup, emplacement construction, rendezvous points, security detachments, transportation means, and routes to emplacement sites.

h. In cooperation with the S4, maintenance of records to show current status of available ADM to include actual locations, unit or installation custodian, and state of readiness.

4-4. Supply Officer (S4)

The supply officer has primary staff responsibility for the provision of ADM and associated equipment. Specifically, the S4—

a. Procures and issues construction materials and required ADM tools, sets, and kits to subordinate units.

b. Coordinates pickup and transportation procedures for ADM through close liaison with the supporting SASP.

4-5. Intelligence Reports

Strategic intelligence studies prepared at the National level by the Department of Defense (DOD) or by oversea commands provide detailed information concerning major geographical areas and are often useful in preliminary ADM targeting. Such studies include—

a. *National Intelligence Surveys*. These surveys present a concise digest of the basic intelligence required for strategic planning and the operations of major units. Each survey describes the pertinent terrain characteristics of a specific area, supported by descriptive material such as maps, charts, tables, and bibliographies.

b. *Engineer Intelligence Studies (EIS)*. These are a series of documents describing in detail those natural and manmade features of an area that affect the capabilities of military forces. These studies are being supplemented and in some cases superseded by DOD and command-initiated lines of communications, port, and terrain-type studies.

c. *Lines of Communication (LOC) Studies*. These studies, prepared on either medium scale

maps or single small scale foldup sheets, contain an analysis of transportation facilities with general information on railroads, inland waterways, highways, airfields, pipelines, ports, and beaches.

d. *Route Reconnaissance Reports*. Most important for terrain information at lower levels are local reports which summarize data obtained by physical route reconnaissance. Such reports are of particular value in providing current, detailed information about routes of communication. The preparation of these reports is discussed in FM 5-36.

e. *Demolition Reconnaissance Records (DA Form 2203-R)*. The preparation of these conventional demolition records is discussed in FM 5-25.

4-6. ADM Target Reconnaissance

a. Successful execution of ADM missions usually depends on prior reconnaissance of the target area and emplacement site. In most cases, ground reconnaissance is required to provide necessary data for detailed target analysis; however, reconnaissance by aircraft can locate potential targets and speed engineer reconnaissance teams to the general target location. The intelligence officer bears staff responsibility for the location and processing of target data. Nevertheless, all combat engineer officers and designated enlisted personnel must recognize potential ADM targets and be familiar with the method of reporting target information.

b. ADM target reconnaissance requires that members of the reconnaissance teams have a general knowledge of nuclear effects and how these effects achieve target damage. The reconnaissance team leader should be capable of determining the governing nuclear effect for each ADM target to insure that appropriate information is reported for complete target analysis. Although ADM are most often used against point targets, the reconnaissance team must not forget that ADM are also capable of large area destruction. Once the characteristics of the specific target are recorded, the reconnaissance team proceeds to investigate the surrounding area for other elements that may be affected by the burst. The location or proposed

location and type of protection afforded to friendly troops in the vicinity of ground zero is vital in planning ADM missions. Other considerations such as the location of nearby forests or population settlements may also be of importance. In cratering, soil type is of critical significance as well as the proximity of by-passes which may reduce an obstacle's effectiveness. Chapter 6 outlines the specific information upon which detailed target analysis is based.

c. Command sites and alternate command sites are selected during reconnaissance (para 4-21). Concealed routes of withdrawal to areas of protection against nuclear effects are also selected for the demolition guard and firing party. Each route is reconnoitered and the withdrawal time noted.

d. If emplacement holes or other emplacement methods beyond the capabilities of ADM teams are required, such information together with an estimate of the number and type of engineers, equipment, and time necessary to prepare the target for demolition is recorded. When aerial delivery of ADM is contemplated, suitable landing areas are also reconnoitered and reported by the reconnaissance party.

e. To facilitate a uniform method of recording and reporting potential ADM targets, reconnaissance forms similar to that shown in appendix IV may be locally produced. Such forms provide uniformity in reporting target information and are designed for electrically transmitted as well as written reports.

4-7. Engineer ADM Training

a. Schools for training ADM specialists have many facilities and aids that are difficult or impossible to duplicate in the field. Engineer units obtain and utilize school-trained personnel whenever possible. Moreover, unit training in coordinated ADM operations must be continuously conducted. On-the-job training is required to develop proficiency in technical procedures and to provide additional qualified specialists. On-the-job training conducted by units should make maximum use of standard and expedient training equipment and school-published training materials to enhance instruction. Personnel must be given instruction on

the unit ADM SOP as well as their individual specialties. Unit training records are maintained as a basis for periodic refresher training.

★b. Skilled personnel and construction equipment may be required to support the ADM firing party by the preparation of the emplacement and command sites. Practical exercises in these functions provide excellent training for the personnel involved. The organization of an element to accomplish the above support functions should be included in the unit SOP. ADM firing party personnel should be cross-trained in all test and prefire procedures to provide depth and, thereby, insure that the team will function efficiently in the event of casualties.

c. In addition to normal training records, engineer units maintain ADM training records. These records reflect the names of personnel qualified to perform prefire and test procedures, their security clearances, their type of training (school trained or unit trained), manuals available in a current ADM reference file, and whether or not personnel have read appropriate manuals and changes.

d. Inspections should be conducted to determine the technical proficiency of personnel and to evaluate other factors affecting the unit's ability to conduct ADM missions. To better determine a unit's ability to deliver and emplace ADM reliably, a nuclear weapons exercise should be conducted as a phase of field exercises. Such exercises, conducted under conditions similar to those expected to be encountered in an actual mission, provide a basis for determining the unit's ability to perform the following:

- (1) Pickup, handling, transporting, and storing munitions.
- (2) Partial storage monitoring.
- (3) Unpackaging and repackaging procedures.
- (4) User maintenance.
- (5) Prefire and test procedures.
- (6) Procedures for delayed or canceled missions.
- (7) Emplacement procedures.
- (8) Accident and incident control and reporting.

- (9) Troubleshooting procedures.
- (10) Preparation and maintenance of records and reports.
- (11) Safety and security procedures.
- (12) Emergency destruction procedures.

★4-8. Transportation of ADM

During transport, engineer personnel normally accompany ADM from the special ammunition supply point (SASP) to the emplacement site. Practically any vehicle of suitable capacity can be used, including Army aircraft or boats, and, for some munitions, pack animals or men, subject to the restriction imposed by paragraph 4-10. Transportation requirements may include lifting and loading equipment for handling the larger munitions. Wreckers, cranes, rail systems, or fabricated ramps are some expedients that may be used. Tactical security considerations determine the vehicular convoy composition and the strength of the security forces necessary for escort. The overall command of the convoy may be specified in the orders to the courier officer, the demolition guard commander, or in the engineer unit ADM SOP if no other unit is involved. To insure reinforcement in case of an emergency, the courier officer or demolition guard commander maintains continuous communication with higher headquarters.

4-9. Storage and Maintenance

a. Depending upon the disposition of ADM, engineer units may be directed to carry ADM as prescribed nuclear load (PNL).

b. Temporary storage of war reserve ADM must meet the requirements listed in appropriate technical manuals and Army regulations (app I). These requirements are for war reserve ADM only and do not pertain to unclassified training items or simulated munitions used for exercise purposes. Except in emergency, ADM are not stored until these facilities are available. However, in fluid tactical situations, increased reliance is placed on the use of armed guards instead of fixed installations.

c. Engineer units having custody of ADM are responsible for certain inspection and maintenance duties. Inspections generally are limited to partial storage monitoring in accord-

ance with the instructions contained in applicable technical manuals (app I). The engineer unit may request advice and assistance from special ammunition units. Also the engineer unit SOP should provide general guidelines in both storage and maintenance procedures.

★4-10. Test and Prefire Procedures

The time required to test and prefire an ADM depends largely upon the proficiency of the demolition firing party. Normally, ADM components remain in the manufacturer's containers as far forward as possible and are unpackaged at the emplacement site. If time and the tactical situation so require, a portion of the test and prefire operations may be performed in a secure rear area. Thereafter, the munition is handled and transported with extreme care so that tests are not invalidated or the munition rendered unreliable. Detailed prefire procedures are contained in the technical manuals for each munition (app I).

★4-11. ADM Denial

a. The primary means of ADM denial is the maintenance of adequate security measures (para 3-24). Under conditions where these measures may not provide adequate denial and capture of the munition is threatened, the senior commander having possession of the munition must take alternative steps to deny it to the enemy. The method of denial chosen will be predicated upon the nature of the threat, the time available to execute denial measures, the environment in which the munition is stored, and the resources available to accomplish denial.

b. The primary, overriding objective of denial of ADM is to render the munition tactically useless to the enemy. Efforts to deny the munition design features and active material to the enemy, if not accomplished concurrently with tactical denial measures, will be attempted only after accomplishment of the primary objective is assured.

c. The most desirable form of denial of a threatened ADM is physical removal from the area of the threat; that is, local repositioning or evacuation. Should such relocation prove impractical concealment such as burial or sub-

mersion, or selective evacuation of sensitive and/or key munition components should be considered. Under no circumstances should munition relocation place the munition or munition component in a more precarious situation.

d. Under emergency conditions where no form of ADM relocation is possible or advisable, and gainful and expeditious employment of the munition against the enemy is impossible, destructive denial becomes necessary. The destructive denial methods for each ADM system are described in the appropriate user technical manual (TM). In general, violent means of destructive denial, by initiation of warhead HE, should be elected if the situation permits this greater degree of destruction to be achieved. If the denial of the threatened munition by violent means is unacceptable, disablement of selected key components provides a simple, rapid, though less effective method of denial of munition tactical utility. Such disablement may be followed by violent destruction to enhance denial of ADM design information and of acquisition of active material if subsequent alterations to the tactical situation permit.

e. ADM are of sufficient importance, and sensitivity, as to warrant the personal concern of and decision by the commanders involved in establishing ADM denial procedures to be followed. Unit SOP instructions for denial should cover all details necessary for the individual who executes them, including:

(1) Origin of the decision to carry out emergency denial. This may include delegation by the commander of authority to execute munition relocation or destruction denial.

(2) Step-by-step procedures including differences in procedures such as may be required in movement, emplaced, in a position of readiness, or at a storage site.

(3) Instructions for the location of necessary denial equipment to insure ready accessibility under all circumstances of storage, movement, in position of readiness, and in firing configuration.

(4) Instructions for the disposition of classified documents such as technical manuals, demolition firing orders, and unit ADM SOP.

4-12. Timer Option

a. To insure positive control and safety for ADM missions in which a timer option is employed, accurate timer calculations are essential. Moreover, in the event of a canceled or delayed mission, it is important for the protection of recovery or disarming personnel that the time of detonation has been precisely determined and recorded. Timers may be used as either a primary or secondary (backup) means of detonation. When timers are employed, it is *not* possible to state that an ADM will fire at a specific time. There is always a time span or *span of detonation* involved.

b. The *span of detonation* is that total period between the earliest possible time of detonation and the latest possible detonation time. This time span is due to the integral timer error. *Early time* is the earliest possible time that the munition can detonate because of timer error. Conversely, *late time* is the latest possible time the munition can detonate. *Fire time* is that time when the munition will detonate should the timers function precisely without error. In other words, *fire time* is that time of day resulting from the addition of the time physically set on the timers to the time of day the timers are started. This *fire time* falls between *early time* and *late time*, but is not necessarily the midpoint in the *span of detonation*. *Starting time* is the actual time that the timers are started. *Set time* or *total time* is the time actually set on the timers and encompasses the entire period from starting time to fire time. An illustration of these time factors appears in figure 4-1.

★c. There are four basic types of timer calculations that the prefire team may be required to make—

(1) Given the starting time and the fire time: find the early, late, and total times.

(2) Given the early and late times: find the starting, fire, and total times.

(3) Given the starting and early times: find the late, fire, and total times.

(4) Given the starting and late times: find the early, fire, and total times.

d. When timers are utilized to back up the remote option, a special problem arises. This

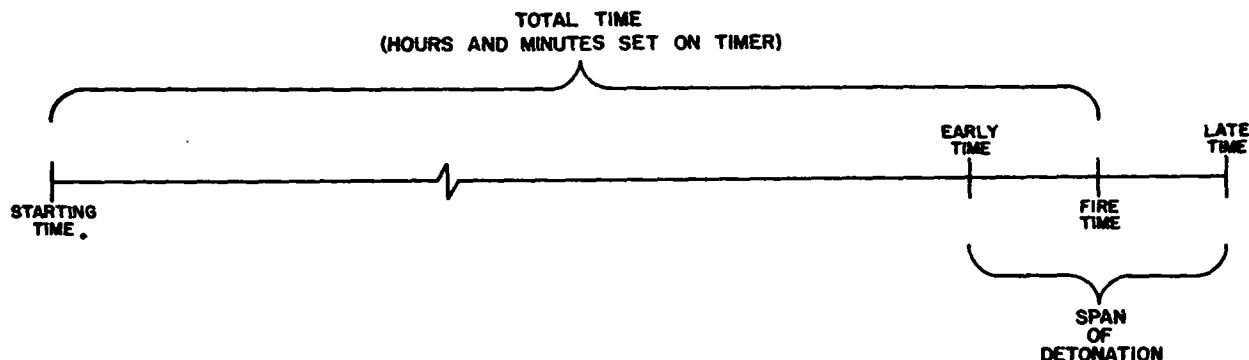


Figure 4-1. Timer calculations.

problem is to calculate the total time physically set on the timers so that they will positively run down and initiate the ADM no earlier than the prescribed *fire time* of the remote

option but as close to that time as possible. The calculation for timer option is accomplished by utilizing the *fire time* with the remote option as the earliest possible detonation time.

Section II. ENGINEER ADM UNITS

4-13. General

To provide ground forces with a capability for atomic demolition munitions employment, engineer ADM teams and platoons have been organized. These ADM units provide technical requisites for the execution of ADM missions; however, additional combat and combat service support must be furnished before mission implementation. Normally, ADM teams are assigned or attached to other combat engineer organizations for logistical and administrative support. Upon receipt of an ADM mission and in accordance with the type, magnitude, and number of targets in the employment area, ADM units usually are attached for command and control to the tactical formation charged with the execution of the mission and for the duration of the specific operational phase. ADM units are capable of providing technical advice for ADM employment; technical supervision in the preparation of sites to meet ADM emplacement requirements; performance of all prefire checks; and, on order, detonation of the munition. The engineer emplacing element may provide physical security for the munition and associated classified equipment. The safeguard-

ing of ADM defense information is a command responsibility which ultimately rests with the ADM unit leader. The ADM unit leader must explain the security precautions required in safeguarding ADM defense information to and coordinate security requirements with the supported unit commander. The supported unit must assist in establishing and meeting these security requirements.

4-14. Atomic Demolition Munition Teams

In order to achieve maximum flexibility and to reduce manpower and training requirements, three types of ADM teams are organized (TOE 5-570). Each team is dependent, however, upon the unit to which attached for combat support, combat service support, and tactical and local security.

a. *Atomic Demolition Munitions Platoon Headquarters, Separate (TEAM MA).*

(1) This team provides qualified personnel and necessary equipment for the command and control of an ADM platoon composed of from two to six atomic demolition munitions teams (MC). The team may be attached to an engineer combat group or battalion (Army),

other U.S. combat units and task forces, or allied military organizations. The team consists of a platoon leader, platoon sergeant, general clerk, radiotelephone operator, and light truck driver.

(2) The platoon leader commands the platoon and is responsible for its training and technical employment. In addition, he serves as a special advisor in ADM operations to the unit to which attached. Upon detachment of subordinate teams for a specific ADM mission and in accordance with the tactical situation and size of the ADM platoon, the platoon leader may assume command of a portion of the platoon placing the remainder of the platoon under the command of the platoon sergeant; or he may conduct liaison between the deployed ADM teams and the supported headquarters coordinating matters of ADM employment and associated matters of communications, supply, and security.

★(3) The platoon headquarters is fully mobile and has organic radios for communications between elements of the platoon and higher headquarters.

b. *Atomic Demolitions Munitions, Liaison (TEAM MB)*. This team consists of an ADM liaison officer and a driver. The liaison officer acts in the capacity of a special staff officer providing technical knowledge and advice for ADM employment. The team may be attached to a U.S. army unit or allied unit which requires technical assistance in ADM employment. When attached to an allied unit necessary communications must be provided by the supported unit. In addition to this staff function, Team MB performs liaison between the headquarters to which attached and other supporting or attached ADM teams. The team is furnished a 1/4-ton utility truck and an AN/VRC-47 radio set.

★c. *Atomic Demolitions Munitions Squad (TEAM MC)*. This team consists of the team leader and four ADM specialists and is responsible for the assembly, preparation for firing, and detonation on order and, if necessary, the recovery, disassembly, or destruction of ADM. The ADM team is dependent on the unit to which attached for ADM storage, resupply, additional transport, tactical and local security,

site preparation, and similar types of combat and combat service support. The squad may be assigned on the basis of one or more to the engineer combat battalion (Army), other U.S. Army combat units and task forces, allied forces, or to increase the capability of the divisional ADM platoon. When two or more of these teams are formed into a platoon, Team MA provides the necessary command and control. Each Team MC is fully mobile and is equipped with sufficient radios for both internal and external communications. The squad may be divided to provide two ADM firing parties under conditions of extensive ADM use. The second firing party must, however, be supported with transport and communications.

★4-15. Divisional ADM Platoon

a. Each engineer battalion organic to the armored, infantry, and infantry (mechanized) division includes an ADM platoon. These platoons include a platoon headquarters and two ADM squads. Platoon headquarters consists of the platoon leader, platoon sergeant, a senior ADM specialist, a radio-telephone operator, and a clerk. Each ADM squad consists of a squad leader, two senior ADM specialists, and two ADM specialists. The platoon is fully mobile and is equipped with sufficient radios for both internal and external communications. The ADM platoons are organized under TOE 5-146 (armored and mechanized infantry divisions) and TOE 5-156 (infantry division).

b. The responsibilities and operations of the ADM platoon leader are similar to those outlined for the platoon leader of Team MA. In addition, the platoon leader serves as a special advisor for ADM technical employment within the division. The capability of the divisional ADM platoon may be augmented by the attachment of one to four ADM squads (Team MC) under which circumstances the platoon leader assumes command of all attachments.

c. The divisional ADM platoon is dependent upon the assistance of the parent engineer battalion as well as other division elements for operational effectiveness. Close coordination is maintained with the engineer battalion staff to insure that procedures are established to provide each ADM mission with adequate and

timely support. The ADM platoon leader maintains particularly close liaison with the engineer battalion operations section and may be

called upon to assist in the technical preparation of the atomic demolition plan and the unit ADM SOP.

Section III. ENGINEER COMBAT SUPPORT

4-16. General

As previously noted, ADM units do not have the capability of conducting independent operations. Successful ADM employment requires detailed staff planning and coordination. Routinely, ADM units are assigned or attached to engineer combat battalions prior to operational employment, and it is the responsibility of these battalion headquarters to insure that efficient ADM standing operating procedures have been established and engineer personnel are trained to effectively accomplish ADM missions. Engineer battalion commanders and staffs continually supervise and coordinate the activities of assigned or attached ADM units. The success or failure of ADM employment rests, to a large extent, on the prior training and efficiency of the supporting combat engineer battalion as a whole. All combat engineer commanders must be familiar with the special considerations of ADM operations and emplacement site preparation, and their units must be ready to respond immediately to the requirements of the specific situation.

★4-17. Security

Local security of ADM normally is furnished by nonengineers. However, it is incumbent on all engineer combat units, platoon and above, to be capable of providing well-trained security guards when called upon. Under certain circumstances, engineers might be required to escort ADM from the pickup site to the emplacement site. Combat engineer units could also be designated as demolition guards, in which case local security of the ADM mission becomes a direct engineer responsibility. Moreover, engineer combat units, based on their close association with ADM, may be called upon to establish basic ADM security procedures for the entire command.

4-18. Construction Support

a. ADM emplacement methods vary from surface bursts to deep underground burial. As

ADM teams have no organic equipment for preparation of emplacement holes, other engineers are often required to support emplacement operations. For example, many ADM emplacement techniques require tamping with sandbags which are most easily supplied by supporting engineers. Engineers may also construct field fortifications for the protection of ADM command sites or improve access routes to emplacement sites. Moreover, the security of ADM sites may be significantly augmented by the installation of mines, barbed wire, and similar obstacles. Such engineer support is beyond the capabilities of ADM teams and is effected through coordination at battalion and higher unit headquarters.

★b. The cratering curves presented in chapter 6 demonstrate the influence of depth of burst on crater dimensions. In tactical ADM operations the depth of burst ordered for a given mission will depend on the effects desired, the tactical situation, and the availability of time, manpower, and suitable construction equipment. Even when burial at optimum depth might not be feasible, burial at depths less than optimum will significantly increase crater dimensions over those obtained from a surface burst. Burial at greater than optimum depth will significantly reduce residual radiation and troop safety restrictions. When time and construction capability permit, such deep burial may permit the use of ADM in situations where it would not otherwise be feasible.

4-19. Methods of Emplacement

★a. Emplacement methods fall under the general categories of deliberate and hasty emplacement. A deliberate emplacement is one which is specifically prepared to optimize the desired effects of a particular munition to accomplish a particular mission. Deliberate emplacement may require the use of tunneling or drilling procedures to provide underground emplacements or the construction of a demoli-

tion chamber at the desired location on a bridge or other surface structure. Hasty emplacement refers to expedient methods of surface emplacement to include attachment of the ADM to existing structures and shallow burial, and the use of existing shafts and tunnels. Hasty emplacements normally are used only when there is insufficient time or equipment available to prepare a deliberate emplacement and will normally require the use of a higher yield and acceptance of greater safety hazards to produce the same degree of destruction.

b. The physical characteristics of ADM and environmental limitations determine to a large extent the possibility of rapid subsurface emplacement. A list of required emplacement diameters for the hypothetical family of ADM as well as their subsurface limitations is presented in table 3-1.

★c. In tactical situations where burial is required while emplacement resources are limited and secrecy is important engineer handtools are used to bury the ADM as deep as practical. In less restrictive situations powered equipment or demolitions may be employed in preparing the emplacement.

(1) The powered earth auger offers a rapid means of excavating emplacement shafts up to 20 inches in diameter and 9 feet deep. This item is organic to the Engineer Light Equipment Company and the Engineer Construction Battalion and also may be available from a Class IV equipment pool.

(2) Steel pipe pile, closed at the bottom, may be driven to considerable depths in some soil media. Where piling of suitable diameter is available it offers an excellent means of emplacement (see para 4-20 on the significance of stemming any emplacement hole, including hollow piling). Engineer construction and construction support units have organic pile driving equipment.

(3) Civilian construction firms and/or commercial drilling equipment may be used for prechambering in certain situations. Rotary drill rigs with special bits and large diameter powered earth augers may be issued to engineer units for digging emplacement shafts.

(4) In appropriate situations military explosives may be used alone or in conjunction

with either powered equipment or handtools to prepare ADM emplacements.

★d. Paragraph 6-7 contains additional information on emplacement criteria.

★4-20. Tamping and Stemming

a. The detonation of an ADM releases energy in all directions. To couple the greatest possible portion of this energy to the target it is necessary to confine the explosion to the maximum extent possible. For a surface or tunnel emplacement this process is called *tamping* and the material used is also called *tamping*. For a subsurface emplacement shaft both the process and the material used to fill the shaft are called *stemming*.

b. Suitable materials for use as tamping or stemming are dry sand, dry gravel, or compacted earth. Sandbags may be used if carefully placed to minimize voids. Other materials such as broken rock or water will provide partial tamping or stemming. In many areas of the world, the height of the ground water table will result in water-filled emplacement shafts. This may be desirable since the water will assist in energy coupling of the explosion into the medium; also, recovery from a water-filled shaft would be much less difficult than from an emplacement hole backfilled with a solid material. Figure 4-2 shows the standard method of stemming a subsurface emplacement shaft.

c. The decision as to the type and quantity of tamping or stemming to be used depends on many factors, among which are—

(1) Type, quantity, and location of materials available.

(2) Time and resources available.

(3) Requirement for insuring recoverability of the ADM in case the mission is canceled.

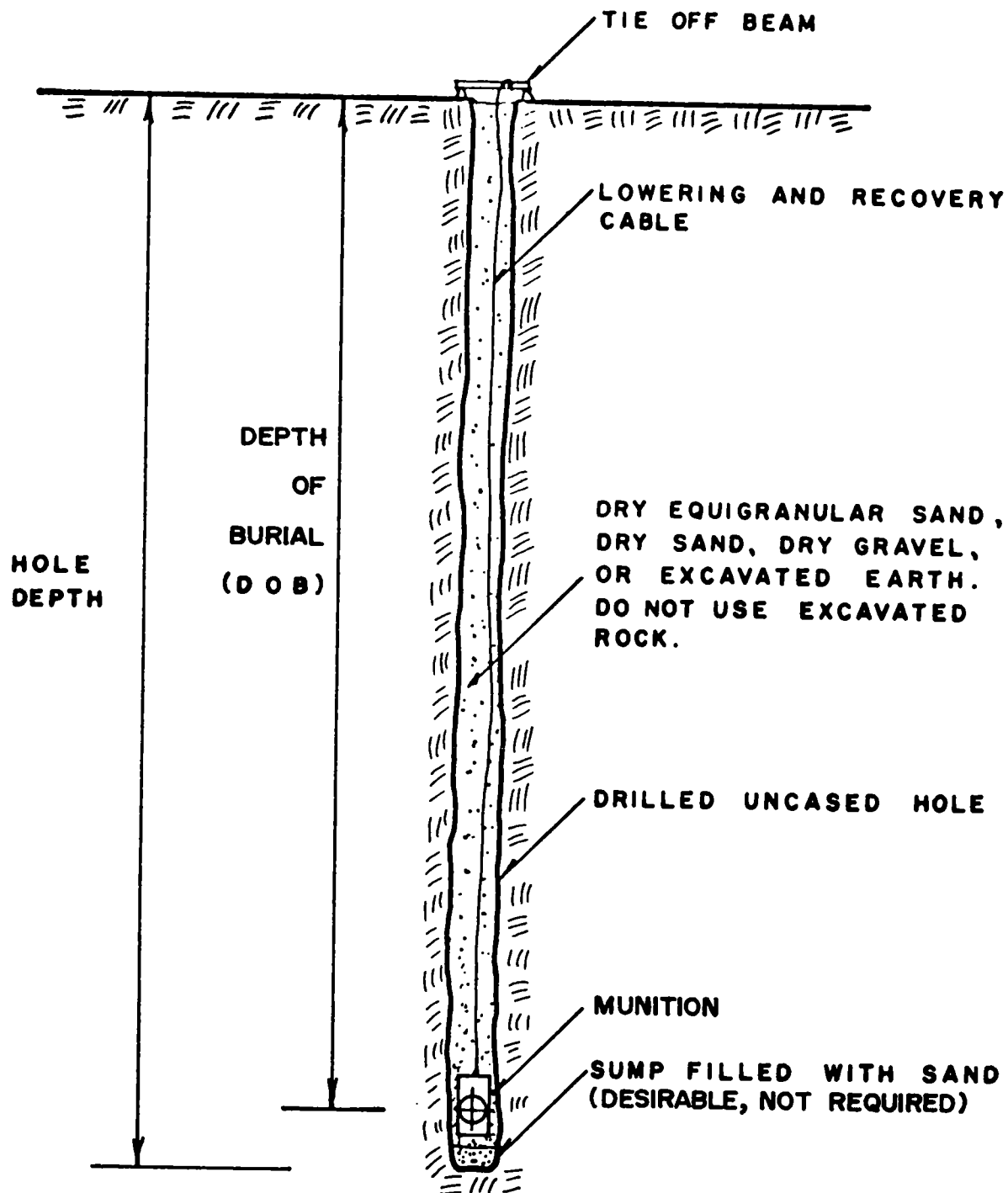
(4) Degree of predictability of effects required.

(5) Capability of the case containing the ADM to withstand pressure of the backfill material.

d. Paragraph 6-7 contains information on prediction of effects when tamping or stemming is less than optimum.

4-21. Preparation of Command Sites

a. Supporting engineer units are often desig-



★Figure 4-2. Stem design for subsurface emplacement of ADM.

nated to prepare primary and alternate command sites. Although priority is given to the preparation of the primary command site, alternate sites are normally planned, coordinated, and prepared. Alternate sites insure completion of the mission, provide flexibility, and permit safe firing under variable meteorological conditions.

★b. Command sites (and any other sites designated for protection of demolition guard or firing party personnel at the time the munition is detonated) are far enough from the ADM to insure that the demolition guard and

firing party are not subjected to initial nuclear effects greater than that specified by the commander. Locations should also consider anticipated fallout although a change in meteorological conditions may dictate detonation of the ADM from an alternate command site. Intervening terrain features may reduce some of the initial nuclear effects; however, provision must be made to keep the emplacement site under observation. If direct observation of the emplacement site is not possible, observation may be maintained by aerial surveillance.



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CHAPTER 5

ADM TARGET ANALYSIS

Section I. GENERAL

5-1. Factors Considered in ADM Target Analysis (STANAG 2130)

a. General.

(1) ADM target analysis is an examination of potential targets and surrounding areas to determine military importance, priority of demolition, and munitions required to obtain a desired level of damage. The purposes of analysis are to compare the respective advantages of conventional and nuclear demolitions in achieving desired target damage, to select the most suitable munition available, to investigate the degree and extent of secondary nuclear effects, and to predict conditions in the target area after detonation.

(2) Nuclear targets are classified according to size, as follows:

(a) *Point targets.* A point target may be either a single element type of target such as a bridge, or it may be an area target whose radius is relatively small in comparison to the radius of damage (about 1 to 5).

(b) *Area targets.* Larger targets which occupy a sizeable portion of terrain are termed area targets.

(3) Predicted results for area targets include the fraction of the target area which is expected to be destroyed and usually is expressed as a percentage. For point targets, damaged chiefly by cratering effects, a brief description of damage is required; *for example:* "center pier of bridge and adjacent spans destroyed."

b. Assumptions. Analysis is based on the following assumptions:

(1) *Reliability.* It is assumed that the ADM will be successfully detonated.

(2) *Area targets.* ADM normally are employed after detailed ground, air, and map reconnaissance of the target area; however, if

detailed information is not available, elements of area targets are assumed to be uniformly distributed.

(3) *Atmospheric conditions.* The influence of atmospheric conditions on initial nuclear effects usually is not considered by the target analyst.

(4) *Terrain.* If a nuclear detonation occurs within a narrow defile, initial nuclear effects may be reinforced within the valley and reduced outside of valley because of the shielding afforded by the terrain.

(5) *Burial.* In many instances, damage is predicated upon adequate ADM burial. In tactical situations, the target analyst must be familiar with the burial capabilities of emplacement units and base his analysis on practical construction limitations.

5-2. Data for ADM Target Analysis

a. Tables in appendix II and FM 101-31-2 present technical data to be used in ADM target analysis. These ADM damage tables provide data for most demolition targets. Troop safety tables and contingent effects tables are also included.

b. *The troop safety tables* simultaneously consider initial nuclear effects and the degree of risk to friendly troops in a particular condition of vulnerability. The tables give the minimum distances that friendly troops must be separated from ground zero to preclude casualties under various conditions of risk and vulnerability. These minimum safe distances (MSD) are based on surface burst initial effects only and do not take into account residual radiation or radiation history (para 5-7).

c. *The damage tables* consider ADM nuclear effects based on surface and/or subsurface bursts. For each ADM, radii of damage against various target elements are shown.

★*d. The contingent effects tables* consider only surface burst effects. For each munition, the tables present the distance to which various effects extend. These effects are—

- (1) Tree blowdown.
- (2) Safety radii for aircraft in flight.
- (3) Fire areas.

e. The tables in FM 101-31-2 have been computed for ADM in the United States stockpile whereas those in appendix II have been computed for a hypothetical family of ADM (table 3-1). The formats, however, are similar. One who understands the techniques of using the unclassified tables can readily make the transition to the classified tables contained in FM 101-31-2.

5-3. Recommendations

a. General. One purpose of target analysis is to select the most suitable ADM for destroying the target under consideration. After target analysis has been completed, the following recommendations are presented to the commander:

- (1) Primary and alternate yields with associated munition types.
- (2) Height or depth of burst.
- (3) Location of ground zero.
- (4) Point of detonation, if applicable.
- (5) Time of burst and firing options.
- (6) Estimated results.
- (7) Troop safety distance.

b. ADM Model and Yield. The ADM model and yield to be employed is represented as shown in table 3-1. For example: BRAVO/1KT/ADM.

c. Height or Depth of Burst. Burst option is normally indicated as surface or subsurface and includes the exact height or depth of burst in meters when applicable.

d. Ground Zero. Ground zero (GZ) is the point on the earth's surface at which, above which, or below which, the detonation will occur; GZ is generally designated by UTM map coordinates.

e. Point of Detonation. In cases where structures are involved, the point of detonation (burst point) is also specified; for example: base of center pier.

f. Time of Burst and Firing Options. The time of burst and firing options are determined by both tactical and technical considerations, such as the scheme of maneuver and timer error; it is shown as a date-time group.

g. Troop Safety. The distance to which the effects for negligible risk to unwarned, exposed personnel extend is portrayed graphically to the commander. If friendly troops are located within this distance, a graphic presentation is provided depicting the resultant risk and/or protection required. (For further discussion of troop safety, see para 5-7 and chap 7.)

Section II. TECHNIQUES OF ADM TARGET ANALYSIS (STANAG 2130)

5-4. General Procedure for Analyzing Targets

The following general procedural steps are those used by the target analyst. They serve only as a guide. Some steps may be omitted or changed in order to meet the needs of the experienced target analyst. These procedural steps closely parallel techniques outlined in appendix B, FM 101-31-1, particularly in those cases where blast damage constitutes the governing ADM effect.

a. Step 1—Identify Pertinent Information.

The target analyst identifies the pertinent portions of the SOP and becomes familiar with the special guidance expressed by the commander. He determines information concerning ADM allocations and information regarding target shape, vulnerability and size, the distance to friendly troops, and target priorities.

b. Step 2—Tentatively Select Point of Detonation.

- (1) Based upon the type of target and other pertinent data, a tentative selection of the point of detonation is made with the realization that troop safety or limiting requirements may necessitate subsequent displacement.
- (2) In selecting the depth of burst or the point of detonation, the following factors are considered:
 - (a) Maximizing the desired effect.
 - (b) Burial limitation of the ADM.
 - (c) Surface contamination (residual radiation).
 - (d) Emplacement capabilities and/or limitations.
 - (e) Firing options.

c. Step 3—Eliminate Obviously Unsuitable ADM. ADM that do not meet weight and/or size limitations imposed by the type mission (for example: munitions too large or heavy to be carried by the mode of transportation available for the mission) are eliminated at this time as obviously unsuitable.

d. Step 4—Determine Data For—

- (1) *Estimating damage to the target.* There are three methods of estimating damage to targets when ADM are employed. Two methods used for predicting damage for nuclear weapons, the visual and numerical method, are also applicable for ADM.

Note. The index method of target prediction prescribed for nuclear weapons is not applicable for ADM.

The third, a special method, encompasses several techniques developed specifically for *ADM targets*. In every

case, the method used depends on the nature of the target (fig. 5-1).

- (a) *Visual method.* Precomputed radii of damage for various target categories are recorded in the damage tables. The target analyst superimposes the appropriate radius over the target and then visually estimates the resultant target coverage in terms of a percentage of the total target area.
- (b) *Numerical method.* The target analyst uses the radius of damage, the radius of target, and the displacement distance, if any, in conjunction with nomographs devised for estimating target coverage. the numerical method must be used for estimating the probability of damaging a point target when blast, rather than cratering, constitutes the governing effect (app. VI).
- (c) *Special ADM methods.* Special methods, based primarily on crater parameters, have been developed for ADM target analysis. Utilizing the data contained in chapter 6, the analyst may estimate the effectiveness of ADM against selected point targets.
- (2) *Troop safety.* The target analyst checks the distance that separates friendly troops from ground zero to insure that they are not exposed to a risk exceeding that stated in the SOP (para 5-7).
- (3) *Bonus effects and limiting requirements.* The target analyst checks bonus effects and makes certain that undesirable results are avoided in the target area. Limiting requirements usually consist of creating obstacles to friendly movement or unacceptable damage to important installations or structures (para. 5-8).

e. Step 5—Eliminate Unsuitable ADM. Any ADM that does not meet the SOP or the commander's guidance is eliminated. If no suit-

able munition is found, revised command guidance and subsequent reanalysis may be required.

f. Step 6—Evaluate Suitability of Munition, Tactical Situation, and ADM Allocation.

- (1) *Most suitable munition.* Considering only the target being analyzed, ADM are listed in the order of their relative capability for meeting the stated requirements.
- (2) *Tactical situation.* All targets being analyzed are listed in their priority

- considering the mission, target importance, and anticipated operations.
- (3) *ADM allocation.* The ADM allocation, the period involved, and the emplacement capabilities are evaluated.

g. Step 7 — Make Recommendations. Considering the priorities determined in *f*(1) and (2) above and the evaluation in *f*(3) above, ADM are recommended for appropriate targets. The recommendation to the commander includes, as a minimum, the items listed in paragraph 5-3a.

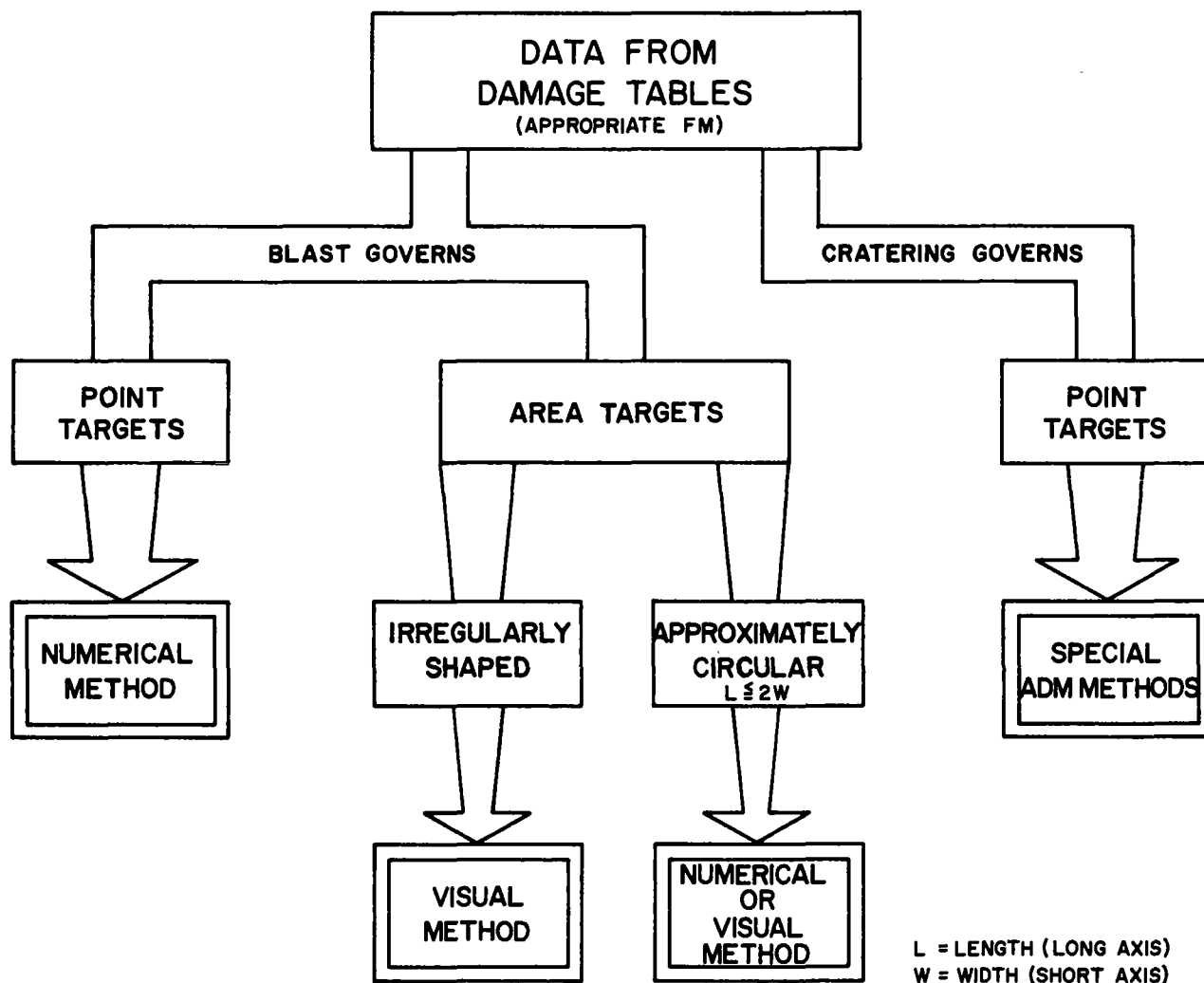


Figure 5-1. Criteria and methods of estimating damage.

5-5. Expected Coverage for Area Targets

a. Damage to area targets may be estimated using either the visual or numerical methods. If an area target is circular or approximately circular, either the numerical or the visual method is used. If an area target is irregular in shape, the visual method is used (app. VI).

b. The unit SOP contains information regarding the extent and level of damage required for specific type targets.

5-6. Probability of Destroying Point Targets

Fractional coverage of a point target has no meaning; the target either receives the level of damage specified or it does not. The probability of destroying a point target is a function of the radius of damage and displacement distance. The probability is determined numerically utilizing the graphs provided in appendix VI

5-7. Troop Safety

a. When compared to conventional explosives, employment of ADM in tactical operations involves a more rigorous analysis regarding the safety of friendly troops (ch. 7).

b. Troop safety may influence the selection of yield, ground zero, time of burst, and scheme of maneuver. When the SOP or commander's guidance concerning troop safety cannot be met, the following corrective actions may be taken to provide the degree of safety desired:

- (1) Move location of ground zero.
- (2) Increase the depth of burial.
- (3) Use a lower yield ADM.
- (4) Withdraw troops to safe distances.
- (5) Accept a higher degree of risk to friendly troops.
- (6) Increase the protection of friendly troops.
- (7) Use conventional demolitions.
- (8) Cancel the mission.

c. The ADM target analyst uses the minimum safe distance (MSD) to make troop safety calculations. The MSD considers the

distance to which certain nuclear effects extend. The following definitions are used in determining the appropriate MSD (app. VIII):

- (1) There are *three degrees of risk* associated with troop safety considerations — *negligible, moderate, and emergency*.
 - (a) At a *negligible risk distance*, troops are completely safe with the possible exception of a temporary loss of night vision or dazzle. A negligible risk from exposure to nuclear radiation is possible only when an individual or unit has an insignificant radiation dose history which will cause no decrement in combat effectiveness. An insignificant accumulated dose is interpreted to mean that blood changes will probably not be detectable. A negligible risk is acceptable in any case where the use of nuclear bursts is desired. *A negligible risk is not exceeded unless significant advantages are to be gained.*
 - (b) At a *moderate risk distance*, the anticipated effect on troops from a single exposure to a nuclear burst is tolerable, or at worst, a minor nuisance. A moderate risk from exposure to nuclear radiation occurs either when an individual or unit has a significant radiation exposure history, but has not yet shown symptoms of radiation sickness, or when a planned single dose is sufficiently high that exposure to up to 4 or 5 doses alone, or in conjunction with previous exposure, would constitute a significant radiation exposure history. A moderate risk is considered acceptable in close support operations; for example, to halt an enemy advance. *A moderate risk is not exceeded if troops are expected to operate at essentially full efficiency after a friendly burst.*

- (c) At an *emergency risk* distance, the anticipated effect on troops from a single exposure to a nuclear burst may result in some temporary shock, mild burns, and a few casualties; however, casualties should never be extensive enough to neutralize a unit. An emergency risk from exposure to nuclear radiation occurs either when a unit has a radiation exposure history which is at the threshold for onset of combat ineffectiveness from radiation sickness, or when a planned single dose is sufficiently high that exposure to up to 2 or 3 such doses, alone or in conjunction with previous exposures, would approach or exceed the threshold for combat ineffectiveness from radiation sickness. An emergency risk should be accepted only when absolutely necessary and should be *exceeded only in extremely rare situations which might loosely be called "disaster" situations*. No attempt is made to define a "disaster" situation. The commander must determine these extremely rare situations for himself and decide which criteria are appropriate to use in attempting to salvage such a situation.
- (2) Closely associated with the degrees of risk is the *vulnerability* of the individual soldier. The danger to an individual from a nuclear detonation depends principally upon the degree to which he is protected from nuclear effects. For example, an individual who is well protected can safely be much closer to ground zero than one in the open. The degree of protection of the individual is dependent upon the amount of advance warning the individual has received. One or more of the following three conditions of *personal vulnerability* can be expected at the time of burst: unwarned, exposed; warned, exposed; and warned, protected.
- (a) *Unwarned, exposed* persons are assumed to be standing in the open at burst time, but have dropped to a prone position by the time the blast wave arrives. They are expected to have areas of bare skin exposed to direct thermal radiation, and some personnel may suffer temporary loss of vision (dazzle).
- (b) *Warned, exposed* persons are assumed to be prone on open ground, with all skin areas covered, and with an overall thermal protection at least equal to that provided by a two-layer summer uniform.
- (c) *Warned, protected* persons are assumed to have some protection against heat, blast, and radiation. The assumed degree of protection is that protection offered to personnel who are in tanks with all hatches closed or crouched in foxholes with improvised overhead thermal shielding. When only a lesser degree of protection is available (*for example*: armored personnel carriers), personnel are not in a warned, protected configuration but are considered as warned, exposed.
- (d) Note that there is no category for *unwarned, protected*. Although protection may be available to personnel, it is assumed that they will not be taking advantage of it unless warned of an impending burst.
- d. In determining the degree of risk to which troops will be subjected, the target analyst needs to know the location of friendly elements, their degree of protection at the time of the detonation and their radiation exposure history.
- e. When examining troop safety in connection with a target analysis, table II-8 (app. II) must be consulted to determine if the

weapon yield being investigated falls in the range where radiation is the governing troop safety criteria. If radiation does not govern, the unit's radiation history does not have to be considered. If radiation does govern, the unit's radiation history must be considered and both table II-8 and criteria of paragraph 7-4 must be consulted. The criteria shown in paragraph 7-4 should be interpreted as follows:

★(1) For units with a past cumulative radiation dose of less than 75 rad (RS-1 units), read direct from Troop Safety table II-8 for the appropriate risk and degree of vulnerability.

★(2) For units with a past cumulative dose of from 75 to 150 rad (RS-2 units), any future radiation exposure must be considered a moderate or emergency risk. There can be no negligible risk for personnel in this category. When investigating troop safety, the negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for moderate risk. Similarly, the moderate risk column must be used for determining emergency risk radii.

★(3) For units with a past cumulative dose of more than 150 rad (RS-3 units), all future exposures must be considered emergency risks. There can be no negligible or moderate risk for personnel in this category. The negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for emergency risk.

★(4) For units located adjacent to zone I or II of the predicted fallout area, exposures up to 20 rad after the onset of fallout could be received. Referring to criteria of paragraph 7-4, if the unit was rated RS-3, this would exceed the emergency risk criteria of 5 rad or less. If the unit was rated RS-2, 20 rad would be an emergency risk. If the unit was rated RS-1, the risk would be only moderate.

5-8. Contingent Effects

a. *Contingent Effects.* Contingent effects are divided into bonus effects which are desirable and limiting effects which are undesirable.

b. *Bonus Effects.* When an ADM is em-

ployed, there are many effects other than the governing effect which assist in destruction. Some bonus effects are predictable, others are not. The target analyst checks to see whether a predictable bonus effect exists at a certain point by obtaining the radius of damage for the effect from the contingency tables.

c. *Limiting Effects.* Limiting effects are those which are undesirable and, consequently, place restrictions on the employment of the munition. These restrictions are referred to as limiting requirements. Examples of effects which may be undesirable are the creation of obstacles to friendly movement as a result of tree blowdown, rubble, forest and urban fires, residual radiation, or undesirable damage in the vicinity of the burst. The target analyst determines whether undesirable effects will be created and determines the radius of the limiting effects from the contingent effects tables.

5-9. Analysis of Specific Target Types

a. The capability of ADM to destroy a specific target depends on many factors, the most important of which is the yield. When making a target analysis and selecting the yield, it is desirable to employ the lowest yield which provides the acceptable degree of damage to the target.

b. In chapter 6 special methods for analyzing ADM targets are presented. General analysis of each target type and specific factors regarding ADM employment are considered. Detailed analysis of typical ADM targets following the procedural steps outlined in paragraph 5-4 are presented in appendix VII.

5-10. Validity of Effects Data

a. Nuclear testing has produced the effects data on which target analysis is based. The validity of these data, however, is extremely variable; when required, validity application of these factors for each nuclear effect is given in TM 23-200. For target analysis purposes, the validity factors are not considered. The target analyst should have an understanding of the accuracy of the data. Refinement of the data or precision in using the data greater than that indicated in the recommended target analysis techniques, therefore, is not justified.

b. Curves and other technical data are provided by the text so that reasonable estimates of yields or damage can be made. The data on which the curves are based have, in general, a degree of accuracy of plus or minus 25 percent.

Knowledge of the cratering effects of ADM is rather limited. As a result, many of the procedures outlined are based primarily on theoretical data rather than empirical observations.

CHAPTER 6

SPECIAL ADM TARGET ANALYSIS

Section I. INTRODUCTION

★6-1. General (STANAG 2130)

Unlike other nuclear systems, ADM are employed to destroy hard targets rather than cause personnel casualties. Nuclear cratering, therefore, is usually the governing effect, whereas other nuclear effects are considered bonus effects, or problems to be controlled or eliminated, depending on the mission. In addition, the unique characteristic of no delivery error considerably simplifies target analysis techniques. This chapter, therefore, presents modifications to the general target analysis methods outlined in FM 101-31-1 and provides special techniques for the analysis of typical hard targets.

6-2. ADM Target Analyst

Since ADM are most often employed to destroy hard targets, the ADM target analyst must not

only be qualified in estimating the effects of nuclear detonations but be familiar with basic construction design. Moreover, the surface and subsurface employment of ADM is significantly influenced by the surrounding soil media. Thus, the ADM analyst must also be familiar with basic soils analysis. ADM target acquisition is similarly diversified requiring not only target location but a detailed description of the target including critical structural dimensions, burial limitations, and soil characteristics. Because of his background and training, the military engineer is well qualified to perform the multiple tasks of troop commander, nuclear target analyst, structural engineer, and soil analyst which are prerequisite to ADM employment.

Section II. TACTICAL CRATERING

6-3. General

One of the potential military uses of ADM of prime significance is the creation of terrain obstacles. The nuclear cratering effect has been previously discussed in general terms in chapter 2. The purpose of this section, therefore, is to present techniques of using ADM to displace large masses of soil or rock to deny land routes of communication in support of tactical operations.

★6-4. Mechanisms of Crater Formation

In order to use the cratering data presented in this manual, the target analyst and engineer should be familiar with the mechanisms of crater formation. Four important processes are involved—

a. The first process is the combined action of

crushing, compaction, and plastic deformation that occurs in the media surrounding the nuclear detonation and is of major importance for bursts at or just below the surface. The large pressures resulting from a nuclear detonation generate a shock wave which travels outward at a high velocity. Some material immediately adjacent to the detonation is melted and vaporized as the shock wave passes through it. The peak pressure in the shock front drops as the wave moves outward and as energy is expended in crushing, heating, and physical displacement. Even at greater distances, the pressures are still of sufficient magnitude to cause deformation in the plastic zone.

b. The second process is spalling. When the underground shock wave encounters a

surface/air interface (e.g., a surface rock formation) as it travels outward, the mechanical phenomenon of spalling occurs. When the compressive stress exerted by the shock wave impinges on a free surface, a layer of the surface material is broken off and moves outward, away from the point of detonation, with considerable velocity. Successive slabs continue to break away until the energy is dissipated below the tensile strength of the material. Rock tends to spall along existing fractures and fissures. Spalling is of great importance in cratering and appears to be dominant for shallow burial ($15 W^{0.3}$ meters or $50 W^{0.3}$ feet).

c. The third process is gas acceleration. The first two processes described last only a fraction of a second. Gas acceleration, however, occurs over longer periods and imparts motion to the material surrounding the explosion by the adiabatic expansion of gases trapped in the cavity. In some instances, particularly for deeper depths of burst, this gas gives appreciable acceleration to the overlying material during its escape through cracks extending from the cavity to the surface as a result of the shock wave. When the expanding cavity encounters the region affected by spall, the gas acceleration increases, elongating the cavity in the direction of the surface. As the cavity breaks the surface it explodes, throwing material into the atmosphere. In many soil types, gas acceleration becomes dominant at optimum ($49 W^{0.3}$ meters or $160 W^{0.3}$ feet) and slightly greater depths of burst. Desert alluvium is a good example of such material. In this soil type, cratering is enhanced by the formation of considerable quantities of steam and gas. Basalt, on the other hand, is an example of a material in which gas acceleration is not so important, as less gas is generated and the spalling effect accelerates the rock faster than the expanding gases.

d. The fourth process, subsidence, is most important for deep burial. This phenomenon occurs at a depth of burst about twice that of optimum burial ($98 W^{0.3}$ meters or $320 W^{0.3}$ feet) or greater. Subsidence is closely linked with the combined process of crushing, compaction, and plastic deformation in the vicinity of the burst point. The expansion of the high

pressure gases generated by the explosion produces a large cavity surrounding the detonation. When the pressure in the cavity decreases to a value where it can no longer support the weight of the overburden, the roof of the cavity begins to collapse. If the material above the cavity is unstable, this collapse will continue until the volume of the cavity is transmitted to the surface, forming a subsidence crater (fig. 2-2). A typical cross section of a subsidence crater is shown in figure 6-1. A subsidence crater is parabolic in shape with approximate dimensions of apparent diameter (D_A) and apparent depth (H_A) as follows:

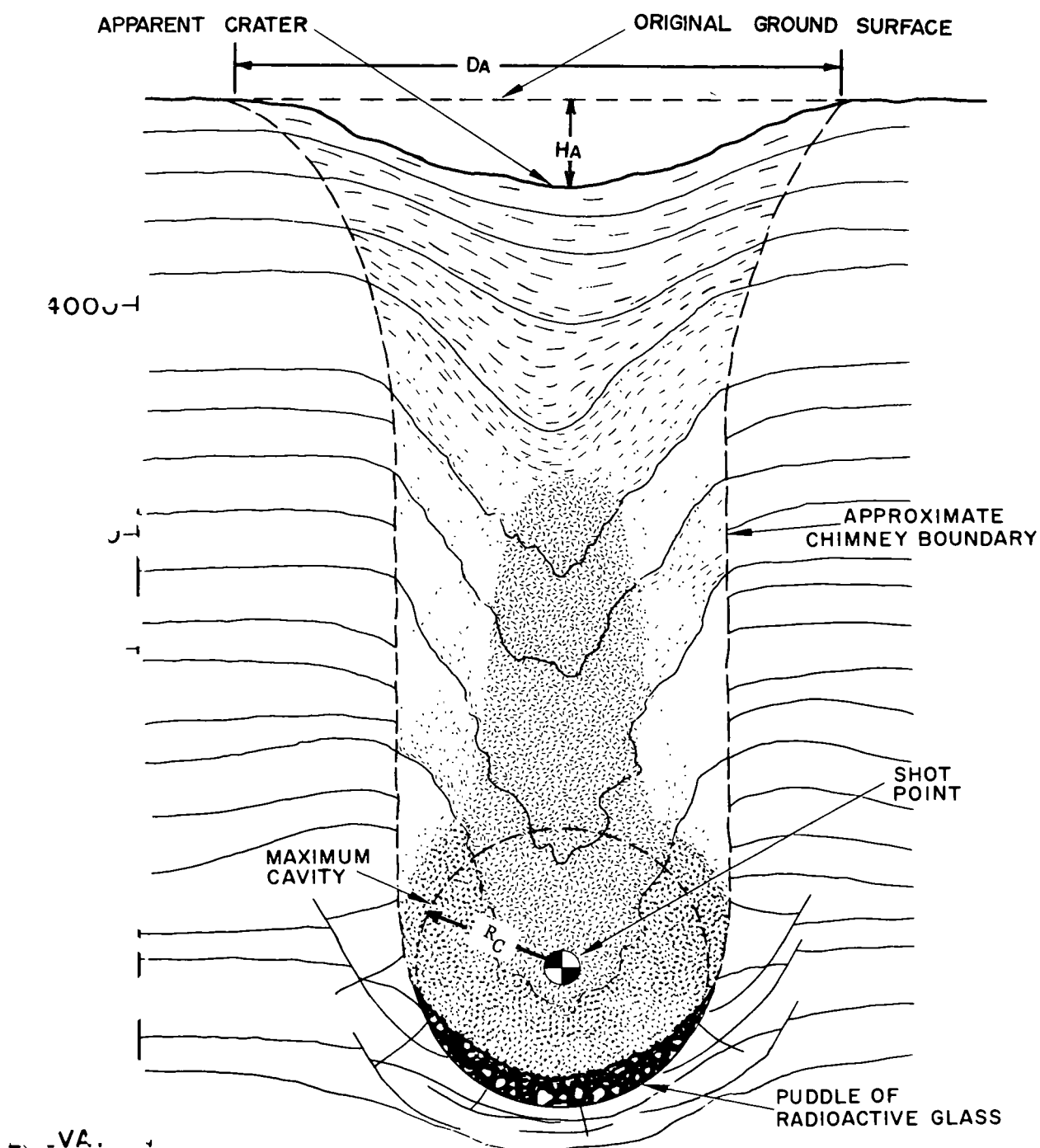
$$D_A = 73 W^{0.3} \text{ meters or } 240 W^{0.3} \text{ feet}$$

$$H_A = 12 W^{0.3} \text{ meters or } 40 W^{0.3} \text{ feet}$$

Subsidence craters are not expected to be formed in hard rock media because there is appreciable bulking of the fractured material which falls into the cavity. In this case, the volume of the underground cavity is not transmitted to the surface but is distributed in the form of voids extending throughout the region of fractured rock. Normally subsidence craters are not used as terrain obstacles because of the gentle slope of the crater wall and the relative uncertainty of crater parameters (see para 6-5e).

6-5. Effects of Depth of Burst and Material Properties

a. *General.* The role that each of the mechanisms described above plays in producing a crater is extremely dependent on the depth of burst. The dimensions of the produced crater, consequently, vary greatly with the ADM depth of burial. As the depth of burst increases, crater dimensions increase to a maximum at some optimum depth, then decrease until a depth of burial is reached where a subsidence crater is formed. The relationships of depth of burial and crater formation are applicable for most soil media. For a given energy yield, however, the maximum crater dimensions differ for various soils and occur at different depths of burst. Some of the properties of the surrounding media affecting the cratering process are the shock transmission characteristics, the tensile and shear strength, the extent of fractures and planes of weakness, mois-



$$\begin{aligned}
 D_A &= \text{Diameter of apparent crater} & R_C &= \text{Radius of cavity} \\
 D_A &= 73 W^{0.3} \text{ meters or } 240 W^{0.3} \text{ feet} & R_C &= 18 W^{0.25} \text{ meters or } 60 W^{0.25} \text{ feet} \\
 H_A &= \text{Depth of apparent crater} \\
 H_A &= 12 W^{0.3} \text{ meters or } 40 W^{0.3} \text{ feet}
 \end{aligned}$$

★ Figure 6-1. Subsidence crater dimensions.

ture content, chemical composition, and density.

b. Surface Burst. The crater is produced primarily by compaction and plastic deformation. Scouring action by the initial gases also contributes to crater formation. The radius is extended to its maximum limit by spalling, but the major process for the depth of the crater and lip formation is the plastic deformation and compression of the material in the rupture zone. Very little fallback is found in a crater of this kind. Consequently, the true and apparent craters are approximately identical.

c. Shallow Burial (approximately $15 W^{0.3}$ meters or $50 W^{0.3}$ feet). At this depth of burst, spalling is the dominant process for the formation of the crater. Gas acceleration and scouring action are only of minor importance. The radius of the crater is determined by the spalling process, whose velocities decrease rather rapidly as the surface radius increases. This decrease of spall velocity folds back the material on the edge of the crater to form a lip.

d. Optimum Burial. Optimum depth of burst normally is taken as that depth of burst at which the crater radius is maximized, (approximately $49 W^{0.3}$ meters or $160 W^{0.3}$ feet). At this depth of burst all three processes (plastic deformation, spall, and gas acceleration) contribute to crater formation. An example of a crater produced at optimum depth of burial in hard rock is illustrated in figure 2-1.

★*e. Subsidence.* Subsidence craters occur at depths of burial about twice that of optimum ($98 W^{0.3}$ meters or $320 W^{0.3}$ feet). The size of the crater is determined by the size of the cavity produced by the detonation. Since the explosion is fully contained, the cavity produced will reach a maximum size, somewhat larger than a normal cratering detonation. The cavity

radius for a detonation in alluvium at a depth of burst of $98 W^{0.3}$ meters ($320 W^{0.3}$ feet), or greater, is approximately:

$$R_c = 60 W^{0.25} \text{ feet or } 18 W^{0.25} \text{ meters}$$

Except in certain soil media, subsidence craters generally have slopes too gentle to provide an effective obstacle to tracked vehicles. Thus their main value would be in denial operations in populated areas, such as cratering airfields or railway marshalling yards. As this type of crater eliminates all militarily significant prompt or residual radiation (including fallout), it can be used where troop safety or radiation considerations preclude other emplacements. This type of crater is also a powerful construction tool, to be utilized in conjunction with such projects as port construction or roadways through difficult terrain.

★6-6. Use of Cratering Curves and Scaling Laws

a. Figure 6-1.1 shows specific crater dimensions and the methods by which they may be derived for actual yields and depths of burst once basic data have been determined by scaling. Definitions of zones of disturbance are given in paragraph 2-18. An empirical 0.3 power scaling law has been derived from past cratering tests. Using this scaling law, yields may be correlated to establish the relationship between crater dimensions and depth of burst by normalizing all dimensions to those applicable to a yield of 1 KT. The depth of burst, apparent crater radius, and apparent crater depth resulting from a given yield are normalized by dividing by $W^{0.3}$. The yield (W) is expressed in kilotons. For ADM detonated on or above the surface, the height of burst, apparent crater depth, and apparent crater radius are scaled as $W^{1/3}$. These relationships are summarized below.

Subsurface burst ($DOB_2 > 0m$)

$$\begin{array}{l} \text{Depth of Burst*} \\ \frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}} \end{array}$$

$$\begin{array}{l} \text{Radius of Crater} \\ \frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}} \end{array}$$

$$\begin{array}{l} \text{Depth of Crater} \\ \frac{H_{A1}}{H_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}} \end{array}$$

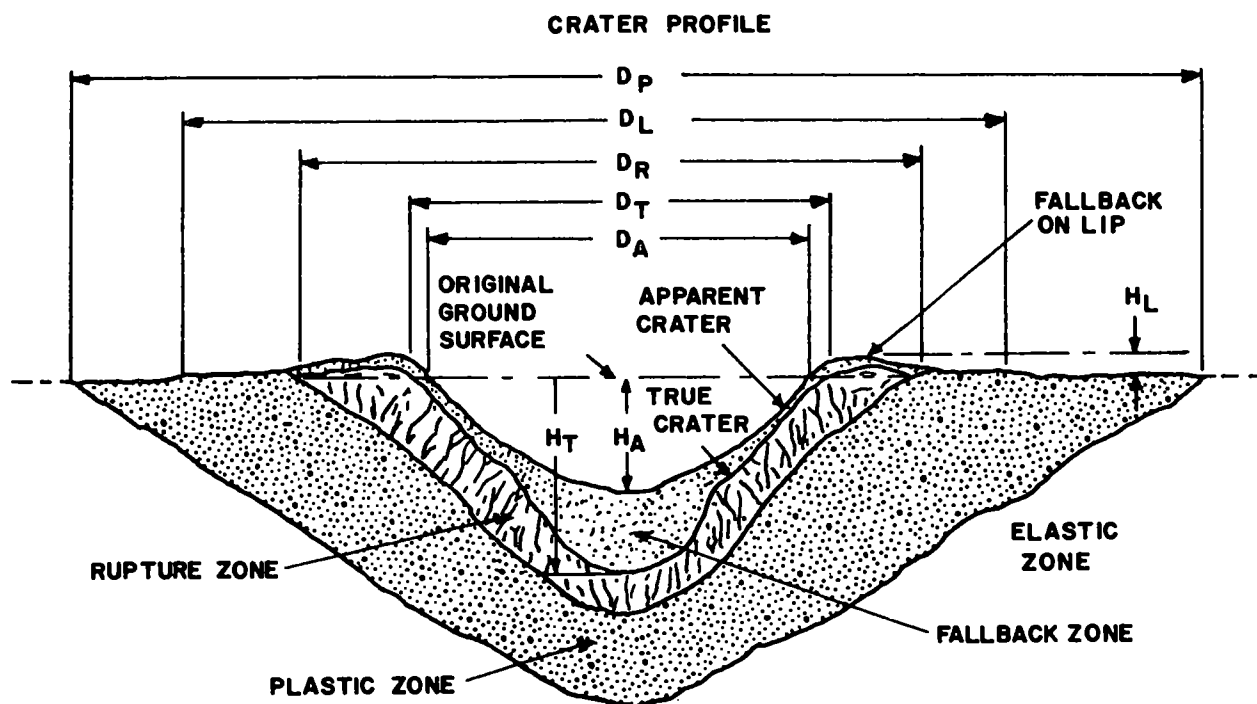
Surface burst ($DOB_2 < 0m$)

$$\begin{array}{l} \text{Depth of Burst*} \\ \frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}} \end{array}$$

$$\begin{array}{l} \text{Radius of Crater} \\ \frac{R_{A1}}{R_{A2}} = \frac{W_1^{1/3}}{W_2^{1/3}} \end{array}$$

$$\begin{array}{l} \text{Depth of Crater} \\ \frac{H_{A1}}{H_{A2}} = \frac{W_1^{1/3}}{W_2^{1/3}} \end{array}$$

*See figure 6-4.1 for effective depth of burst for DOB_1 to be used for various emplacement configurations



D_A = DIAMETER OF APPARENT CRATER

H_A = DEPTH OF APPARENT CRATER

D_T = DIAMETER OF TRUE CRATER

H_T = DEPTH OF TRUE CRATER

D_L = DIAMETER OF LIP = $2.0 D_A \pm 25\%$

R_A = RADIUS OF APPARENT CRATER = $\frac{D_A}{2}$

R_C = RADIUS OF CAVITY

$R_C = 45(W)^{1/3}$ FT OR $14(W)^{1/3}$ METERS

H_L = HEIGHT OF LIP = $0.25 H_A \pm 50\%$

D_R = DIAMETER OF RUPTURE ZONE
= $1.5 D_A \pm 25\%$

D_P = DIAMETER OF PLASTIC ZONE
= $3 D_A \pm 50\%$

V_C = VOLUME OF APPARENT CRATER

$$V_C = \frac{\pi}{2} H_A (R_A)^2$$

$H_T = DOB + R_C$

Figure 6-1.1. Crater dimensions.

b. Figures 6-2 through 6-4 give crater radius and crater depth as a function of depth of burst for various soil types. These curves are for a 1 KT ADM. The scaling laws given above must be used to find these dimensions for yields other than 1 KT. These curves assume that the emplacement of the ADM meets the criteria for standard emplacement as given in paragraph 6-7b.

★6-7. Effects of Tamping and Stemming

a. General. The manner in which the ADM is tamped or in which the emplacement shaft is

stemmed determines the manner in which the energy from the explosion is coupled to the surrounding media. Thus several feet of tamping around a surface emplacement will result in a significantly larger crater than would be produced by the same munition in an untamped emplacement. Similar considerations hold true when comparing the effects of subsurface bursts in stemmed and unstemmed shafts. A minimum of 1.5 meters (5 feet) of earth covering should be placed over an ADM whenever possible.

b. Standard Emplacement Configurations.

The curves given above (fig. 6-2—6-4) are based on the following criteria: for a "surface burst" (depth of burst equals zero) it is assumed that the ADM is resting on the surface of the ground and that no cover is provided; for a "subsurface burst" it is assumed that the emplacement shaft is completely filled with dry sand or earth.

c. Nonstandard Emplacement Configurations. Predictions of crater parameters for nonstandard emplacement configurations are based on theoretical analysis and very limited experimental results. Figure 6-4.1 shows both standard emplacement configurations and those nonstandard configurations for which meaningful prediction can be made at this time. Pertinent information governing the prediction of crater dimensions in each case is also shown.

d. Expedient Surface Emplacements. There is evidence that relatively small variations in surface emplacement configurations have great effects on crater parameters. For this reason it is important to insure that surface emplacements conform to those shown in figure 6-4.1 and that expedient emplacement, such as the bed of a truck or trailer be rigorously avoided.

★6-8. Cratering in Various Media

Cratering data for various substances have not been fully developed. Sound engineering judgment and knowledge of the operational area are desirable in estimating specific crater dimensions. In this text, cratering data are provided for various media as follows:

a. Dry Soil and Soft Rock. Figure 6-2 gives the estimated apparent crater dimensions as a function of depth of burst for 1 KT bursts in dry soil or soft rock.

b. Hard Rock and Concrete. By using a multiplication factor of 0.8, the crater curves for dry soil and soft rock (fig. 6-2) may be used for depths of burst down to optimum. This relationship cannot be used for depths of burst below optimum.

c. Wet Soils.

(1) *Unconsolidated.* Marine muck typifies wet, sedimentary material and is composed of soft, very moist silts, clays, and organic deposits. These deposits usually are gray to blue if primarily silt, and yellow if primarily clay;

figure 6-3 shows cratering curves for this soil type.

(2) *Compacted.* Residual clay typifies material which consists of a compact, slightly plastic, cohesive clay. It is a residual product which has been developed by rapid rock decomposition inherent to regions of heavy rainfall, warm climate, and rank vegetation. The residual clay curves (fig. 6-4) are used to predict crater dimensions in wet clay. A lower limit water content of 25 percent is used as the classification criterion for wet clay. Dry soil curves (fig. 6-2) are used to predict crater dimensions in soils with a moisture content less than 25 percent.

6-9. Apparent Crater Characteristics

a. Shape of the Apparent Crater. The shape of the apparent crater varies significantly with the depth of burst of the ADM. Craters resulting from surface detonations have gentle slopes and are relatively shallow in depth while detonations in the vicinity of optimum depth of burst produce craters with relatively steep slopes. Although the shape of the apparent crater varies with depth of burial, the crater cross section remains approximately parabolic.

b. Apparent Crater Lip. The apparent crater lip consists of the material lying above the original preshot ground surface. Formation of the apparent lip results from the upward displacement of the ground surface and the deposit of throwout material around the periphery of the crater. The upthrust portion of the lip is defined as the true crater lip, while the material deposited on top of the true crater lip (ejecta) combines with the true lip to form the apparent crater lip. The characteristics of the apparent crater lip depend on the yield, depth of burial, and the media in which the detonation occurs. Lip height and diameter achieve their greatest dimensions in rock media.

★6-10. True Crater Characteristics

a. General. The true crater is defined as the boundary between the fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The charac-

teristics of the true crater are of primary interest to the engineer when considering military applications involving the demolition of hard targets.

b. True Crater Radius. The true crater radius is defined as the radius of the circle that best describes the intersection of the preshot ground surface with the walls of the true crater. For depths of burst less than optimum, the true crater radius and the apparent crater radius are approximately equal.

c. True Crater Depth. The expansion of the high-pressure gases generated by a nuclear explosion in soil or rock produces a cavity surrounding the detonation. The depth of the true crater is equal to the depth of burst of the ADM plus the radius of the cavity created by the detonation. The ultimate cavity size depends on the growth rate of the cavity, the propagation velocity of the stress wave produced by the detonation, the depth of burst, and the yield of the ADM. In the range of yields and depths of burst of interest to the military engineer, the cavity radius is approximately equal to—

$$R_c = 45 W^{1/3} \text{ feet}$$

or

$$14 W^{1/3} \text{ meters}$$

$$R_c = \text{cavity radius}$$

$$W = \text{device yield in kilotons}$$

The true crater depth, therefore, may be determined from the equation:

$$H_T = DOB + R_c = DOB \text{ feet} + 45W^{1/3} \text{ feet}$$

$$H_T = \text{true crater depth}$$

$$DOB = \text{depth of burst}$$

d. Shape of True Crater.

(1) The shape of the true crater varies with depth of burial. The true crater profile for depths of burst up to $15 W^{0.3}$ meters (50 $W^{0.3}$ feet) is approximately parabolic.

(2) For depths of burst greater than $15 W^{0.3}$ meters, the outline of the cavity becomes discernible and the sides of the true crater approach a conical configuration.

(3) The true crater shape of subsidence craters is approximated by a cylinder of radius 10 percent greater than the cavity radius and a depth slightly greater than the depth of burial.

e. True Crater Lip. The lip of the true crater is formed from the upward displacement of the

ground surface arising from the expansion of the cavity formed by the energy released from the device. The amount of displacement that occurs is dependent upon the properties of the soil media, the ADM yield, and depth of burial. As the depth of burial is increased to optimum, the height of the true crater lip is significantly increased.

★6-11. Characteristics of Rupture and Plastic Zones

a. Rupture Zone in Rock Media. The rupture zone resulting from a cratering detonation in a rock medium extends beyond the true crater boundaries for varying distances depending upon the scaled depth of interest. For shallow or optimum depths of burial directly below the ADM where the confining pressures are high, the rock may be fractured to a distance of 1.5 cavity radii ($1.5 R_c$) from the point of detonation. The sides of the rupture zone in the vicinity of the point of detonation may extend to 3 cavity radii ($3 R_c$). The rupture zone at the surface extends approximately 1.5 times the radius of the crater ($1.5 R_A$) from ground zero. Figure 6-5 shows the probable shape and extent of the rupture zone in rock.

b. Plastic Zone in Rock Media. Since the fracture and yield stresses in most rock media are almost equal, the plastic zone, if it exists at all, extends only slightly beyond the rupture zone. The boundaries of the plastic zone are roughly parallel to the rupture zone boundaries. In rock media, the plastic zone has essentially the same strength and permeability as the undisturbed rock.

c. Characteristics of Rupture and Plastic Zones in Soil. The extent of the disturbed region resulting from an explosion in soil media is determined primarily by the shearing stresses produced by the detonation. When a soil medium is subjected to shearing stresses greater than the shearing strength of the soil, plastic deformation occurs. Since the material in both the rupture and plastic zones of a soil medium is subjected to permanent deformation as a result of shear failure, it is most difficult to differentiate between the rupture and plastic zones.

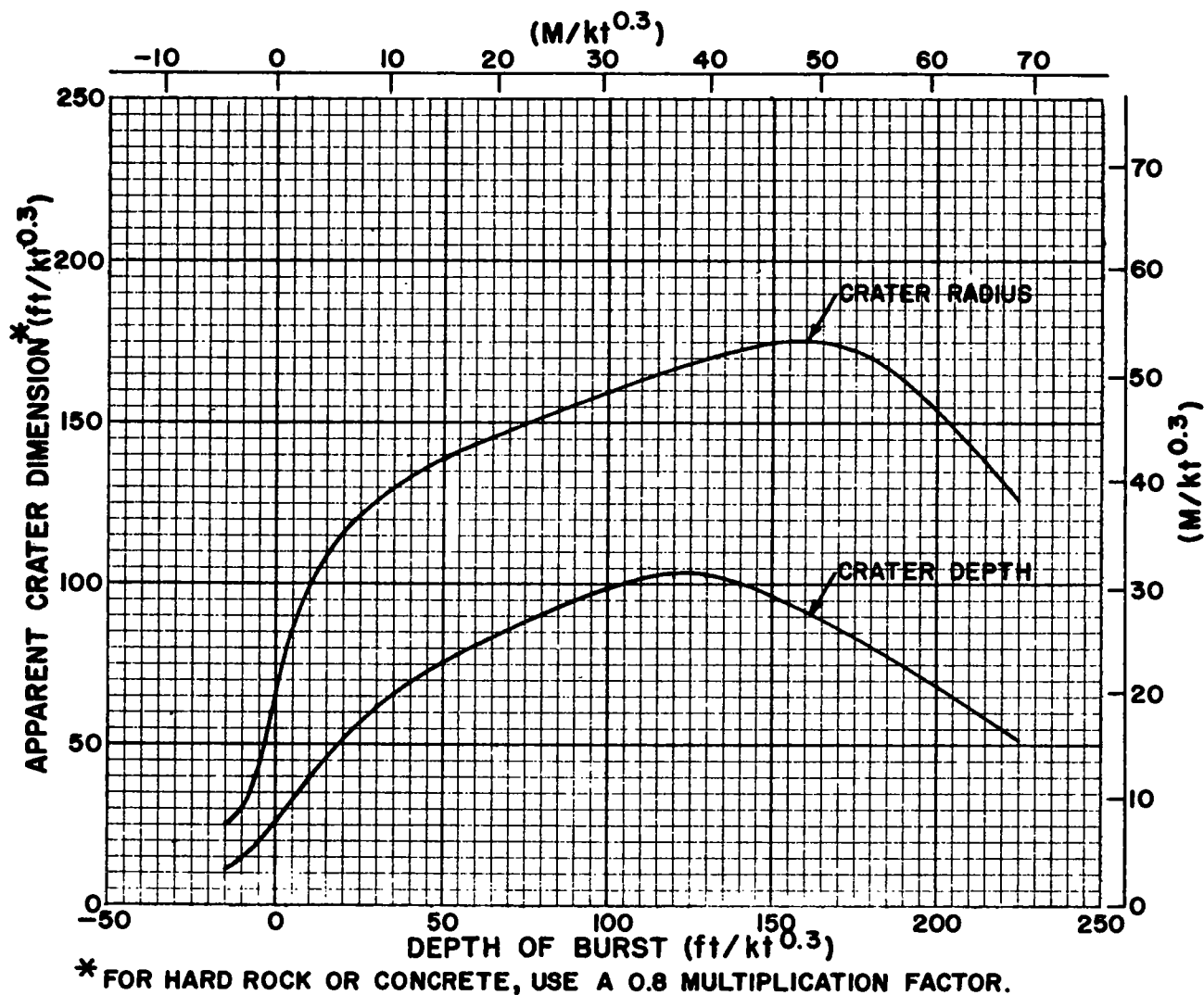


Figure 6-2. Apparent crater dimensions versus depth of burst in dry soil or soft rock (normalized to 1 KT).

★6-11.1. Craters as Obstacles

a. *Crater Properties and Shape.* The effectiveness of a crater as an obstacle depends primarily on the slope of the crater sides and the properties of the medium cratered. The depth of loose material on the crater sides and the moisture content of the soil become important factors at near critical slopes. Test results indicate that a slope of approximately 30° is critical for tracked vehicles in dry soil (desert alluvium). More gentle slopes may be negotiated by such vehicles without assistance, where as

greater slopes require that some type of assistance be provided. Craters produced at the same scaled depth of burial in the same media generally will have the same shape cross section regardless of the yield. In dry soil, the critical slope for tracked vehicles will occur at depths of burial of 0 meters and greater. In hard rock, such as basalt or granite, the size of the rubble in the crater may be expected to preclude vehicle passage without regard to the steepness of the slope.

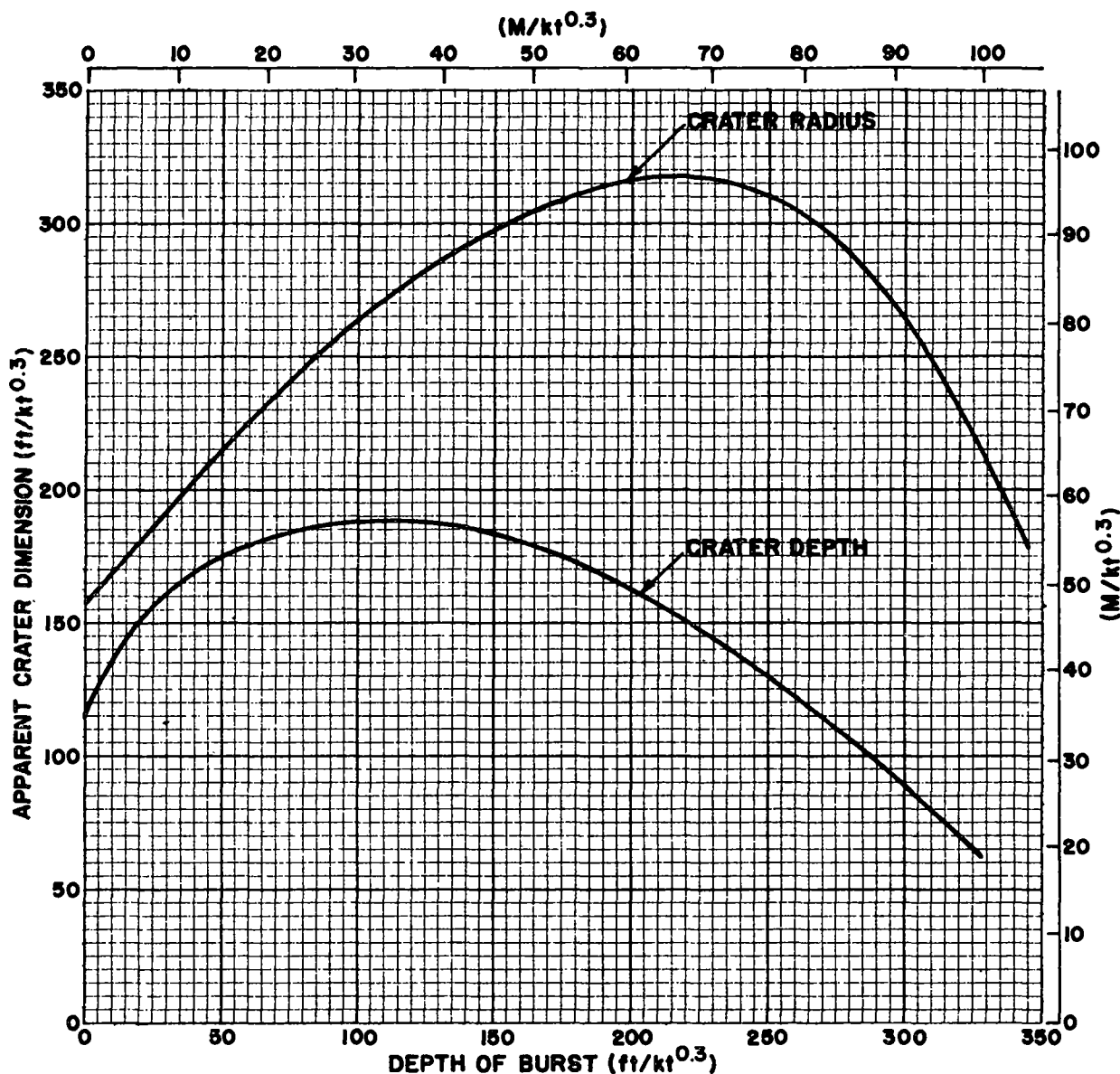


Figure 6-3. Apparent crater dimensions versus depth of burst in marine muck (normalized to 1 KT).

b. Optimum Burial. The most effective depth of burial to produce an obstacle to tracked vehicles is optimum depth of burial ($49 W^{0.3}$ meters or $160 W^{0.3}$ feet). In addition to producing maximum crater radius, optimum burial produces other cratering effects which could be used to advantage in ADM employment.

(1) Maximum uplift of the rupture zone producing higher lips.

(2) Maximum ejecta of material contributing to lip height and obstacle value.

(3) Steepest crater slopes, reducing trafficability.

(4) Maximum crater volume, increasing breaching time.

(5) Large reduction of thermal and initial nuclear radiation effects.

(6) Large reduction of air blast effects.

(7) Underground containment of most residual radiation (fallout).

(8) Higher concentration of induced radiation.

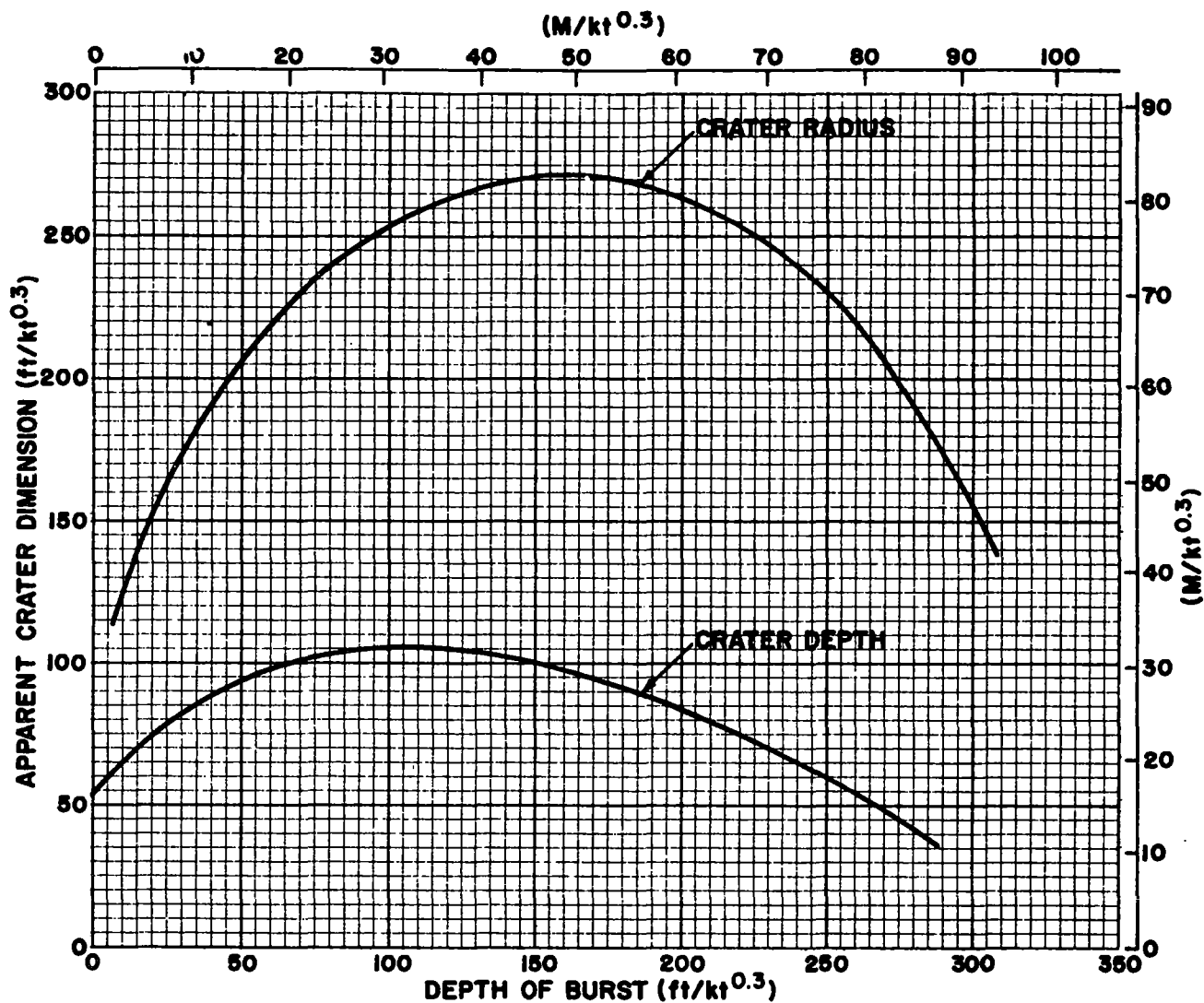
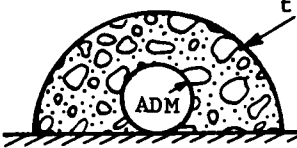
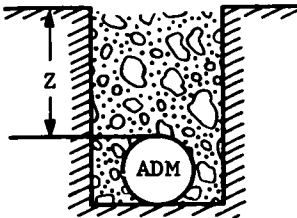
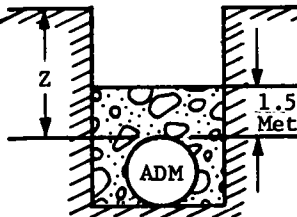
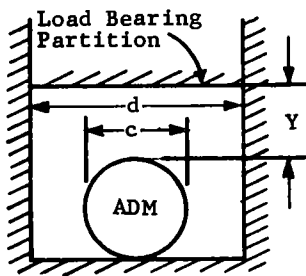


Figure 6-4. Apparent crater dimensions versus depth of burst in residual clay (normalized to 1 KT).

	CONFIGURATION	SCALED EFFECTIVE DOB	REMARKS
A		DOB=0	1. Standard surface emplacement for purposes of calculation only. 2. <u>NOT</u> recommended for field use.
B		$DOB_1 = \frac{t}{3W^{0.3}}$	1. Muniton case resting on ground surface. 2. "t" must equal 1.5 m (5 feet) or more. 3. Subtract "t" from calculated crater depth.
C		$DOB_1 = \frac{Z}{W^{0.3}}$	1. Standard subsurface emplacement. 2. Range of use: $0 \leq Z \leq \text{optimum}$.
D		$DOB_1 = \frac{Z}{3W^{0.3}}$	1. Range of use: $1.5 \leq Z \leq 45W^{0.3m}$.
	DETAIL 1 	Same as for configuration C or D, as applicable	1. This detail shows maximum internal dimensions for a structure built to protect the munition when depths of burial shown in paragraph 3-5d are exceeded. 2. $Y \leq 0.5$ Meters. 3. $\frac{d}{c} \leq 1.5$ Meters.

NOTE: A minimum of 1.5 meters (5 feet) of tamping or stemming should be placed over any ADM whenever possible.

★Figure 6-4.1. Emplacement configurations.



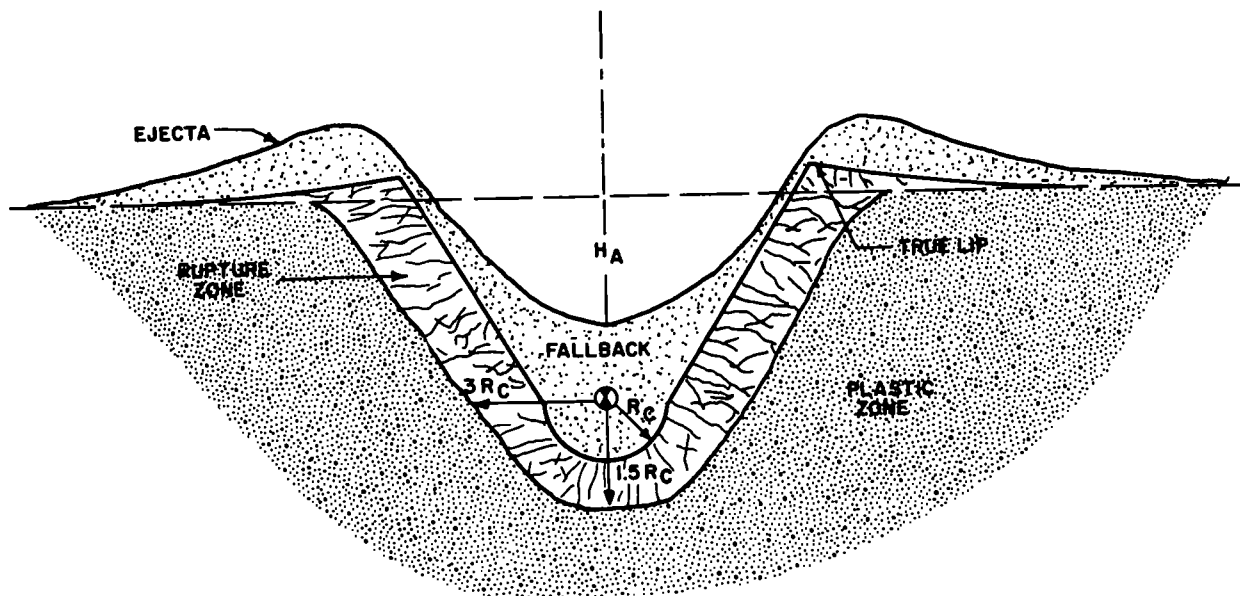


Figure 6-5. Typical crater cross section in rock showing shape and extent of rupture zone.

6-12. Demolition of Earthfills

a. Emplacement Criteria. Earthfills which support roads and railroads are generally constructed of granular soils such as sand and gravel—sometimes with a clay binder. The dimensions of fills vary in accordance with the width of the route and the topography of the area. The recommended ADM emplacement positions for demolition of earthfills are—

- (1) Placement under the center of the fill in a culvert passing through the fill (position 1, fig. 6-6).
- (2) Placement at some depth beneath the crest of the fill (position 2, fig. 6-6). ADM burial depth depends on the availability of time, the nature of the soil, the type of available construction equipment, and the tactical situation.

- (3) Placement on the crest of the fill (position 3, fig. 6-6).

b. Yield Selection.

- (1) The yield required to destroy earthfills is determined principally by the width of the fill and depth of burial of the ADM. The yield must be sufficient to create a crater with a diameter at least as large as the crest width. *The curves for cratering fills (fig. 6-7), however, do not take into account such tactical considerations as the minimum gap required to preclude spanning by vehicular-launched bridges or the depth of crater required to stop track vehicles.* Both are important considerations especially when the crest width is comparatively narrow and placement is on the crest of the fill. In such

cases, or if the crest width exceeds 30 meters (100 feet), the target is better analyzed using data in appendix II and FM 101-31-2.

- (2) Figure 6-7 provides yield selection curves for varying depths of burst and crest widths. To use the curves, enter figure 6-7 with the depth of burst at which the detonation will occur and read vertically upward until the proper B curve (width of

crest) is intercepted. From the point of interception of the DOB line and B curve, read horizontally to the left to determine the yield required. If the DOB line does not intercept the B curve, then the smallest available ADM (.01 kt) is adequate to produce the required crater diameter for depths of burst less than optimum (12.5 meters or 41 feet).

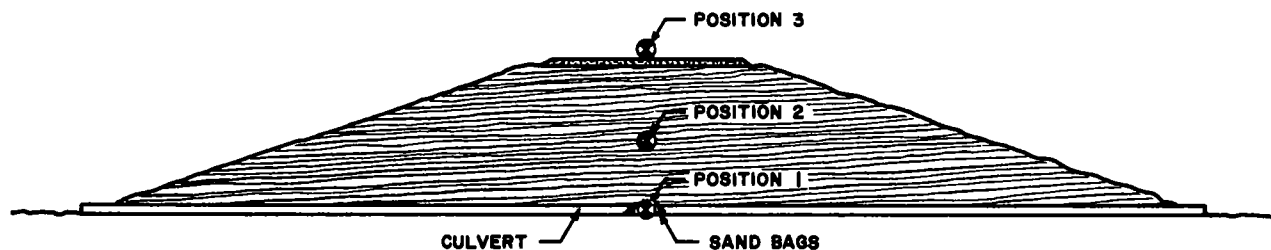
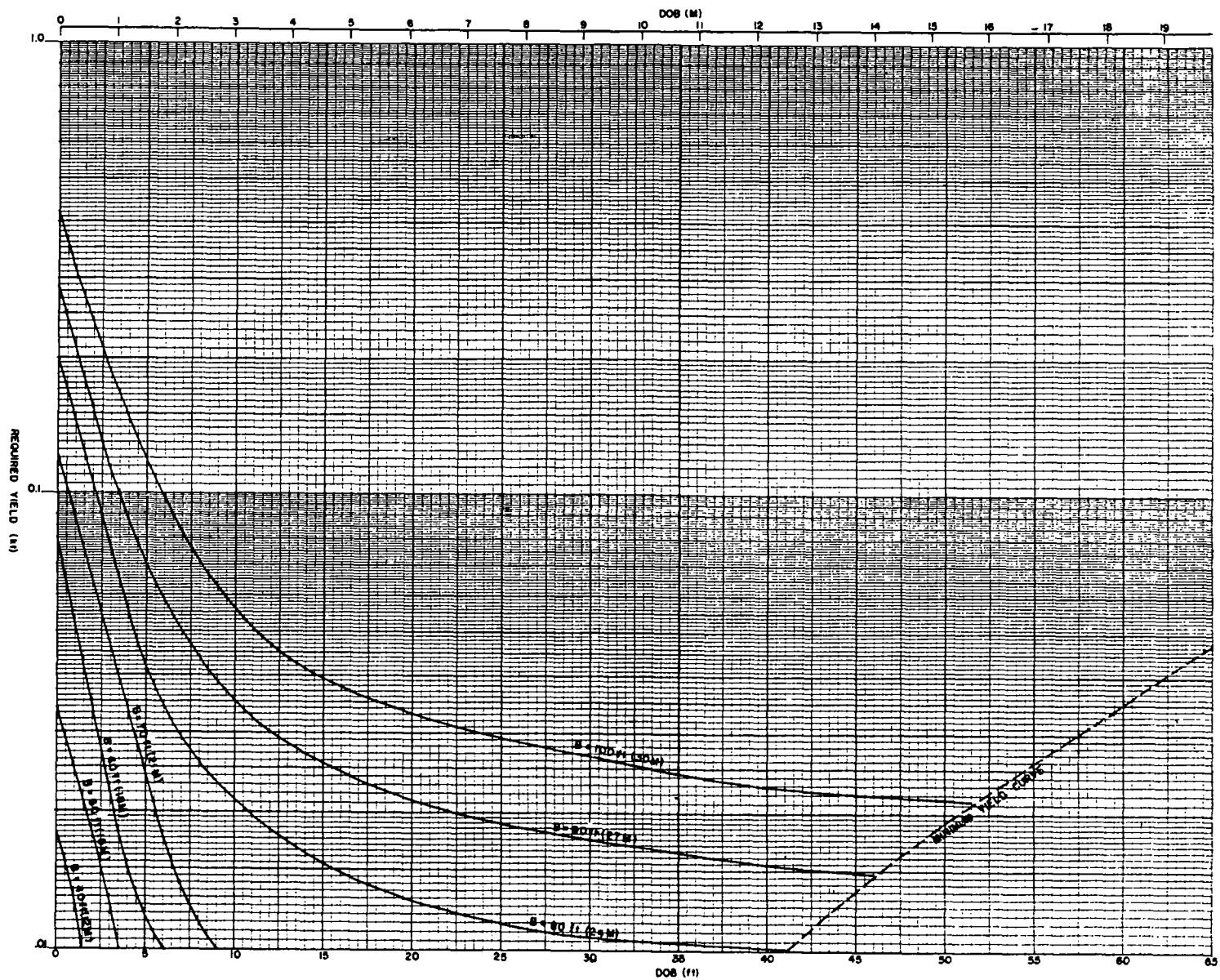
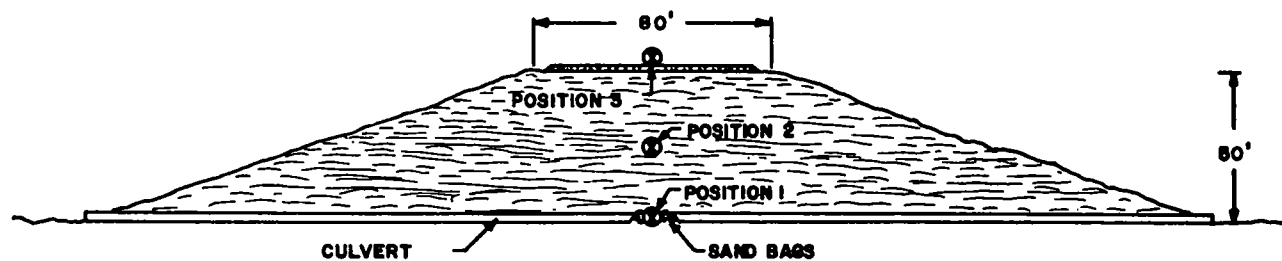


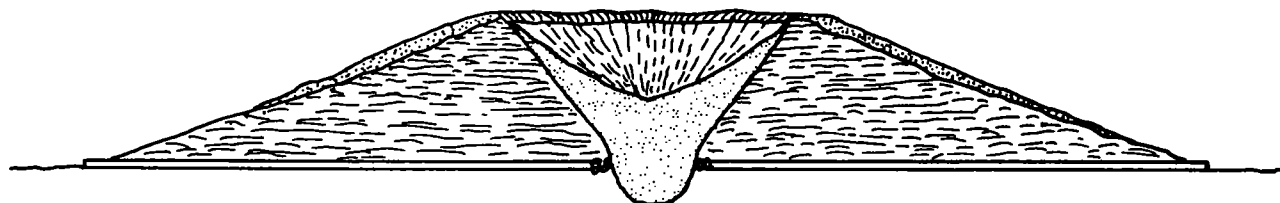
Figure 6-6. Cross section of earthfill showing ADM emplacement positions.



★Figure 6-7. Yield selection criteria for cratering fills.



PRESHOT SKETCH OF EARTH FILL FOR ILLUSTRATIVE EXAMPLE



POSTSHOT SKETCH OF EARTH FILL FOR ILLUSTRATIVE EXAMPLE, POSITION 1

Figure 6-8. Earthfill for illustrative example and crater resulting from detonation in position 1.

c. Illustrative Example. The following example illustrates the recommended procedure for determining ADM yields required to demolish earthfills:

Given: An earthfill with dimensions as given in figure 6-8 is to be destroyed utilizing nuclear explosives. There are three possible emplacement positions: (1) in the culvert at the center of the fill; (2) at a depth 25 feet beneath the crest; and (3) on the crest.

Find: The yield required to demolish the earthfill at each of these positions.

Solution: Position 1—Emplacement in the Culvert. DOB = 50 feet and width of crest (B) = 80 feet. It is apparent from figure 6-7 that the DOB = 50-foot line does not intercept the

B = 80-foot curve. The minimum yield, therefore, is determined by moving vertically along the DOB = 50-foot line until the minimum yield curve is intercepted. Reading to the left from the point of interception, the minimum yield is 0.018 kt.

Position 2—Emplacement at DOB = 25 Feet Below Crest. DOB = 25 feet and width of crest (B) = 80 feet. Using figure 6-7, the yield required for DOB = 25 feet and B = 80 feet is .012 kt.

Position 3—Emplacement on Crest of Fill. DOB = 0 and width of crest (B) = 80 feet. Using figure 6-7 for DOB = 0 and B = 80 feet, the required yield is 0.19 kt.

6-13. Demolition of Earth and Rock Defiles

a. Emplacement Criteria.

- (1) *General.* The emplacement positions and yield requirements for blocking defiles depend primarily on the steepness of side slopes and width of cut. The side slopes of manmade cuts in rock are generally constructed with relatively steep slopes greater than 45°. Because of soil stability, the side slopes of manmade cuts in soil, on the other hand, are necessarily gentle unless retaining walls are used.

(2) *Steep-sided cuts.*

- (a) Access through steep-sided cuts is denied by blocking the cut with a crater equal to the width of the cut. Since steep slopes will preclude any crater lip from forming along the toe, consideration should be given in such cases, to the formation of a crater having a *lip diameter* rather than crater diameter equal to the width of the cut. The ADM may be detonated on the surface in the center of the cut (position 2, fig. 6-9). The crater produced by the surface detonation denies passage to wheeled vehicles and causes considerable delay to tracked vehicular traffic. However,

detonation of an ADM in this position is not as effective as detonating the munition below the surface.

- (b) Emplacement of the munition beneath the toe of the slope to create a landslide and thereby block the cut is very effective if emplacement capabilities permit. The details of this technique are discussed in paragraph 6-14.
- (3) *Earth cuts with gentle side slopes.* The recommended emplacement position to deny access through earth cuts with gentle slopes (less than 45°) is below the center of the cut position 1, fig. 6-9). If it is not possible to emplace the ADM below the ground, the ADM is detonated on the surface at the center of the cut (position 2, fig. 6-9). Emplacement beneath the toe of the slope is not recommended because the soil above the crater will probably remain stable and not slide into the cut nor will the volume of *ejecta* be sufficient to block the cut.

b. Yield Selection. Yield requirements for the emplacement positions shown in figure 6-9 are determined by the width of the cut. The yield must be sufficient to produce a true crater diameter equal to the width of the cut in soil and/or a lip diameter for rock cuts (app. II).

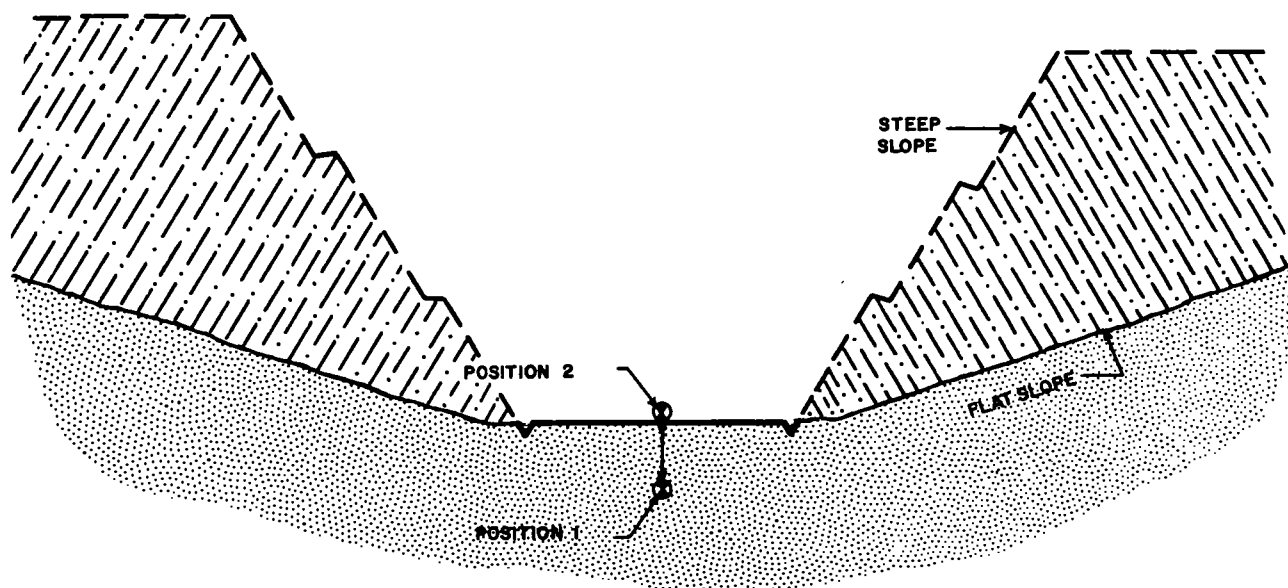


Figure 6-9. Cut with steep/flat side slopes showing recommended ADM emplacement positions.

6-14. Creation of Landslide Barriers in Defiles

a. General. Access through defiles may be denied by detonation of an ADM in the toe of a side slope. The detonation blocks the defile by ejecting throwout material from the crater into the defile and by producing an unstable condition in the material overlying the crater so that landslide occurs.

b. Topographic and Geologic Features. In selecting a site for creation of a landslide barrier, the engineer should attempt to find a location that has the following geologic and topographic features:

- (1) *Topography.* The ideal topography for the initiation of a slide barrier is a relatively deep and narrow defile with nearly vertical walls. In any event, one of the side slopes should be at least 45° .

(2) *Geology.*

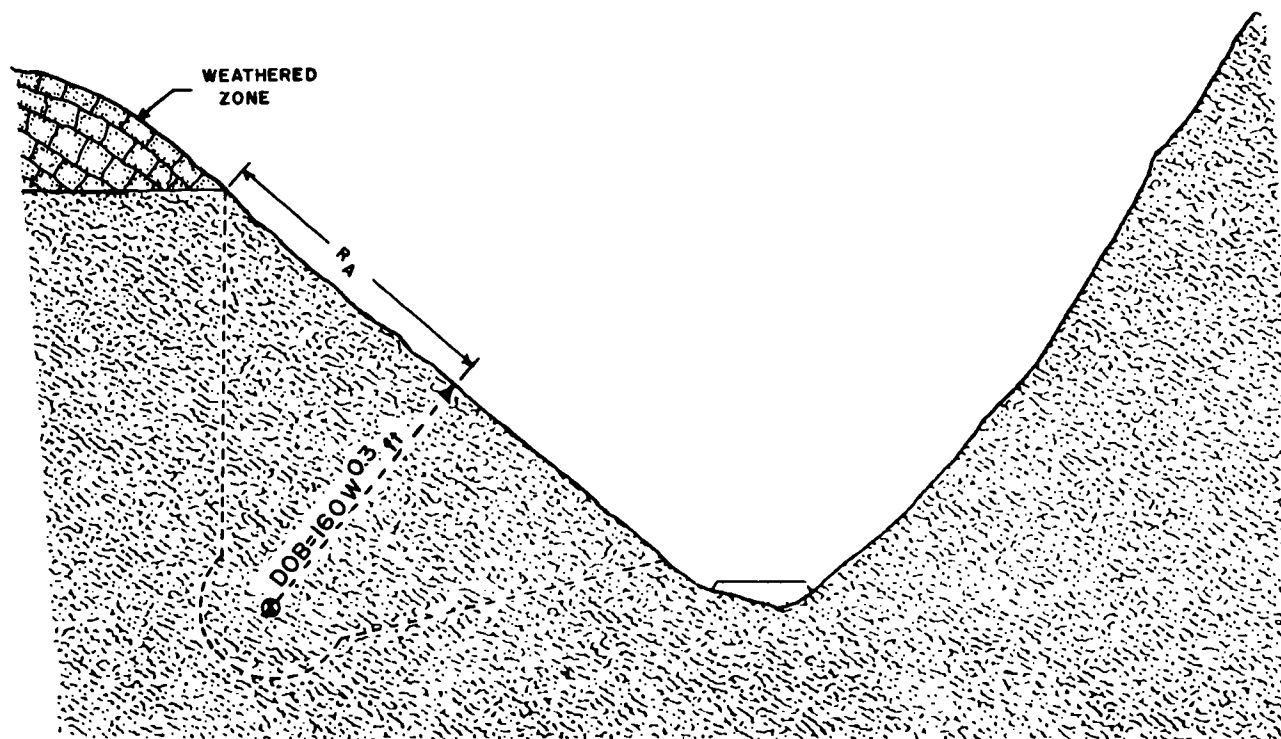
- (a) A site with geologic features which

are conducive to slide initiation has a highly weathered and jointed valley wall of relatively weak rock with bedding planes dipping toward the valley floor (TM 5-545). If material of this nature is subjected to the forces of a cratering detonation, it will most likely break loose and slide down to the valley below.

- (b) Particular emphasis is placed on the location of joints, faults, weathered zones, and similar geologic features which affect the response of the media to the detonation. Engineer intelligence reports, terrain studies, and the experience of a military geologist are particularly useful in locating suitable emplacement sites.

c. ADM Placement and Yield Selection.

- (1) The ADM is emplaced under the toe of the slope so that the detonation



★Figure 6-10. Recommended ADM emplacement position for initiation of landslides.

heaves the slope material outward and slightly upward.

(2) The device is emplaced at approximately the same elevation as the defile floor as shown in figure 6-10.

★(3) The depth of burst of the device is near optimum for crater radius ($160 W^{0.3}$ ft or $49 W^{0.3}$ m) measured perpendicular to the slope as indicated in figure 6-10.

(4) The existing geologic features must be given strong consideration in selecting the ADM yield. Generally it is desirable to select a yield of such a magnitude that the true crater boundary produced by the detonation intercepts any weathered zone or plane of weakness as shown in figure 6-10. The true crater radius required to insure that the true crater boundary intercepts the weathered zone is deter-

mined from the geometry of the slope, and the required yield is then calculated.

d. Illustrative Example. This example illustrates the procedure for determining the location, yield requirement, and emplacement location for ADM employment to initiate a slide in a defile.

Given: The barrier plan requires the denial of access through the defile shown in figure 6-11.

Find: The location, required yield, and emplacement location for use of an ADM to create a landslide barrier in the defile.

Solution:

(1) *Location selection.* After careful reconnaissance of the defile, the site indicated on figure 6-11 is selected for the following reasons:

(a) It is located at the narrowest point in the valley floor.

(b) The slope of the valley wall is 46° which is greater than the minimum recommended slope for slide initiation.

(2) *Site description.* A vertical cross section through the selected site is shown in figure 6-12. The valley walls consist of dry soil and soft rock. The weathered zone is located at a vertical distance of 380 feet from the valley floor.

★(3) *Yield selection.* The distance from the valley floor to the weathered zone measured along the slope of valley wall is 600 feet. The true crater radius, therefore, must be at least 300 feet so that the crater boundary intercepts the weathered zone. The radius, considering optimum depth of burial in dry soil for a 1-kt munition, is 175 feet (fig. 6-2).

True crater radius = apparent crater radius (R_A) (para 6-10).

$$R_{A1} = 175 \text{ feet}$$

$$R_{A2} \text{ (required)} = 300 \text{ feet}$$

$$\frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

Substituting:

$$W_2^{0.3} = \frac{300 (1)^{0.3}}{175} = 1.72$$

$$(W_2^{0.3})^{3.33} = (1.72)^{3.33}$$

$$W_2 = 6 \text{ kt}$$

The closest acceptable ADM yield to 6 kt as given in table 3-1 is—

$$W_2 = 10 \text{ kt}$$

The radius for a yield of 10 kt, using the scaling relationship from above, is—

$$R_{A2} = \frac{(175) (10)^{0.3}}{(1)^{0.3}} = 350 \text{ feet}$$

★(4) *Emplacement position.*

(a) The ADM is emplaced at a scaled depth of 160 feet (DOB_1) (See fig. 6-2) meas-

ured normal to the face of the valley wall to optimize the crater radius.

$$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

Substituting:

$$DOB_2 = \frac{(160) (10)^{0.3}}{1^{0.3}} = \frac{(160) (1.99)}{1} = 320 \text{ feet}$$

(b) The ADM is positioned under the toe of the slope at a distance of 320 feet measured normal to the face of the slope and is placed at approximately the same elevation as the valley floor as shown in figure 6-12. Emplacement of the ADM in this position requires construction of a horizontal emplacement tunnel.

(5) *Probable cratering and landslide sequence.* Upon detonation, material inside the true crater is moved outward. Some of this material is ejected several hundred feet into the defile. Immediately thereafter, the material above the true crater boundary begins to fail so that a new slope is formed behind the existing one. As the material slides and tumbles downward, the true crater cavity is filled with a portion of the rubble. The remaining material and the *ejecta* from the initial crater forms a barrier across the valley floor. The height of the barrier produced by the detonation depends to a great extent on the manner in which the material behind the existing slope fails and on the steepness of the newly formed slope. Figure 6-13 shows the vertical cross section of the valley as it might exist following the detonation.

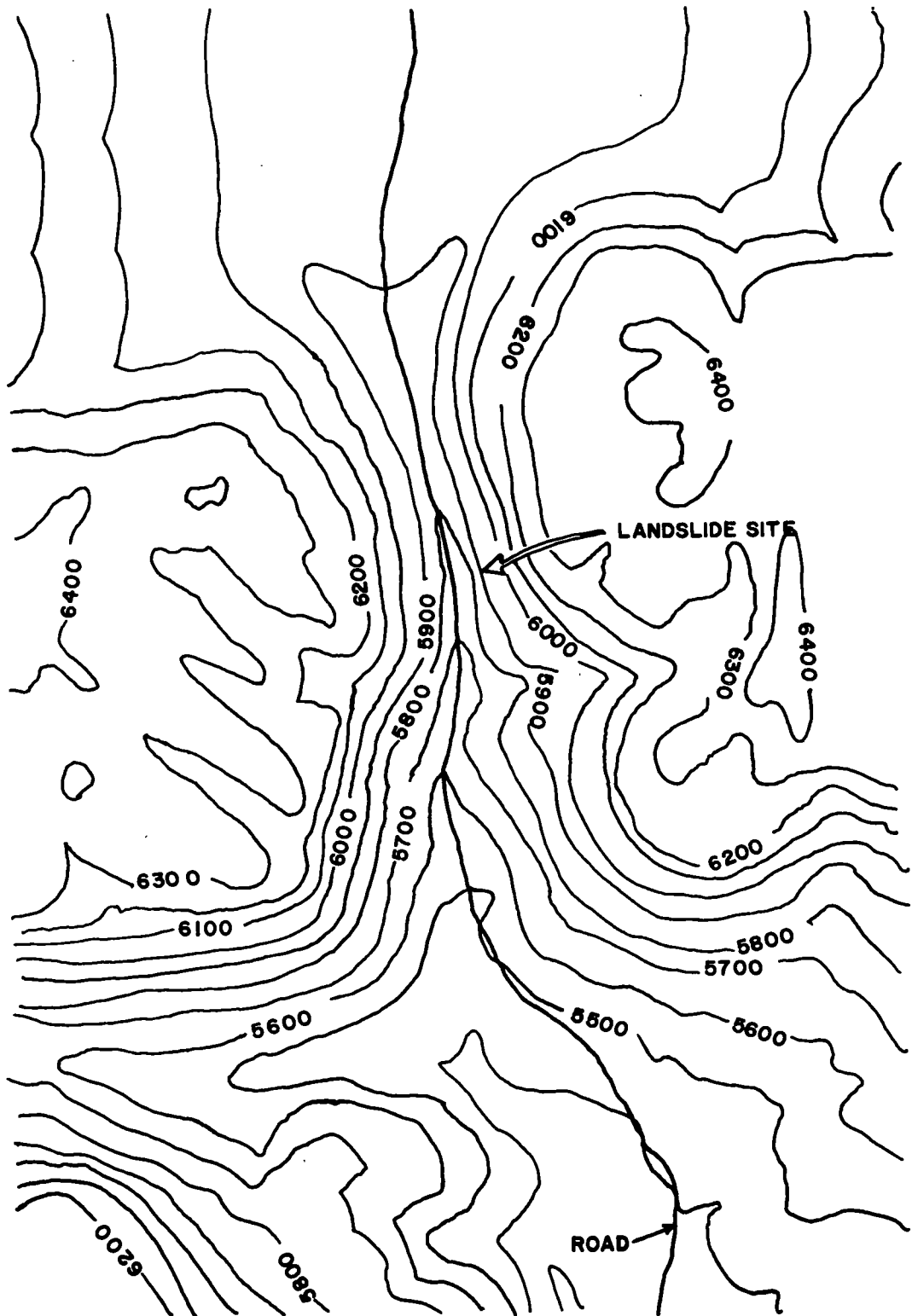


Figure 6-11. Map of defile described in illustrative example.

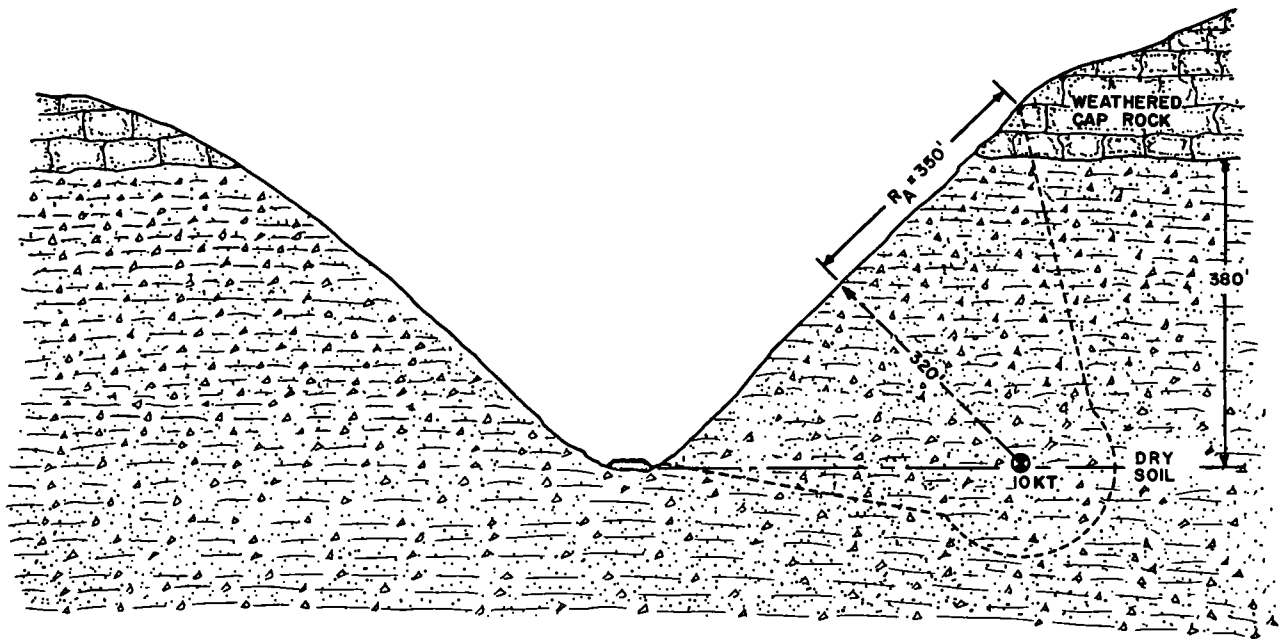


Figure 6-12. Cross section through defile at landslide site (illustrative example).

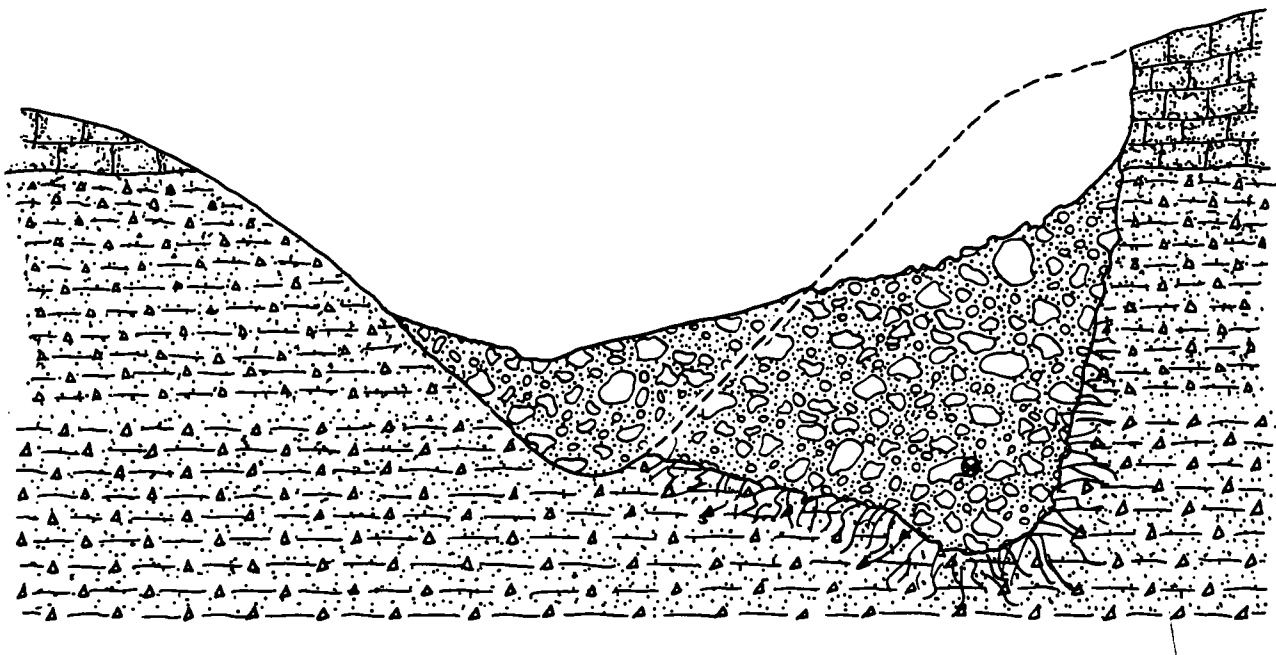


Figure 6-13. Blockage of defile resulting from landslide initiation.

Section III. BRIDGES

6-15. General

a. This section provides a guide for the use of ADM in fixed bridge demolition. There are many cases in which bridges may be quickly and efficiently destroyed with conventional explosives, and such possibilities should always be considered before expanding critical nuclear material. However for the purposes of this text, bridge demolition is assumed to be a task calling for ADM.

b. Bridge demolition begins with an examination of bridge construction. In order to effectively destroy a bridge with minimum yield, manpower, time, and equipment it is necessary that the target analyst be familiar with the various types of bridges, how they are constructed, and the location of vulnerable points. Consequently, nine basic types of steel and concrete bridges are examined. Timber bridges are not mentioned since they can be effectively destroyed by conventional demoli-

tions. Also, extremely large bridges of suspension or cantilever type are not discussed.

6-16. Bridge Types

a. *Steel Construction.* Steel bridges are grouped in three classifications: truss, plate girder, and arch.

(1) *Steel truss.*

(a) *Through truss* (fig. 6-14). This is a common bridge type employed earlier in this century but is seldom used in contemporary bridge construction.

(b) *Deck truss.* This type uses trusses below the traveled way and is also not common in modern construction. Deck trusses are employed mostly as railroad trestles but may be occasionally found as approach spans to larger highway bridges.

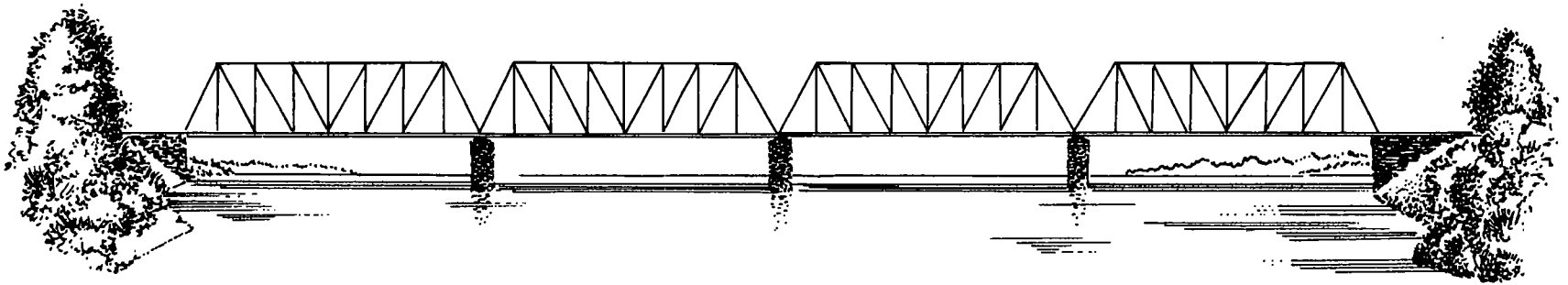


Figure 6-14. Steel through truss bridge.

(2) *Steel plate girder.*

(a) *Through plate girder* (fig. 6-15).

This type, formerly used for railroad bridge construction, is still in use but to a lesser extent. Principal

support is provided by two longitudinal plate girders which also serve as side railings. Steel cross-beams connect the side girders and support the traveled way.

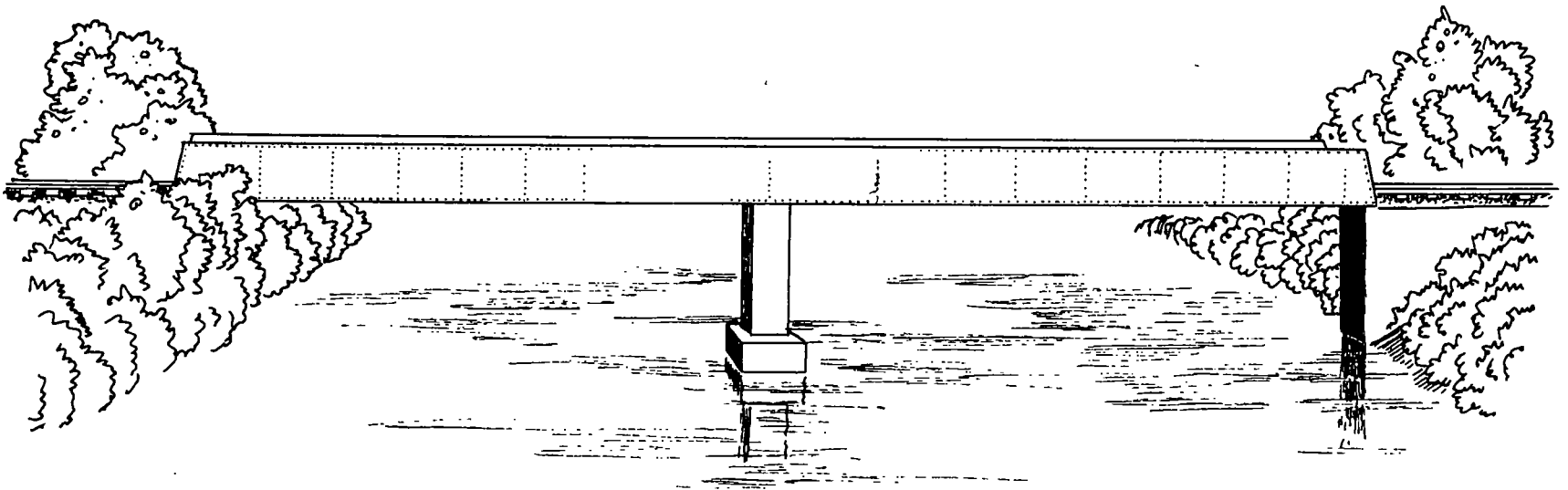


Figure 6-15. Steel through plate girder bridge.

(b) *Deck plate girder* (fig. 6-16). This type construction is often used in contemporary construction. Plate

girders with or without cross bracing are strung parallel to and support the traveled way.

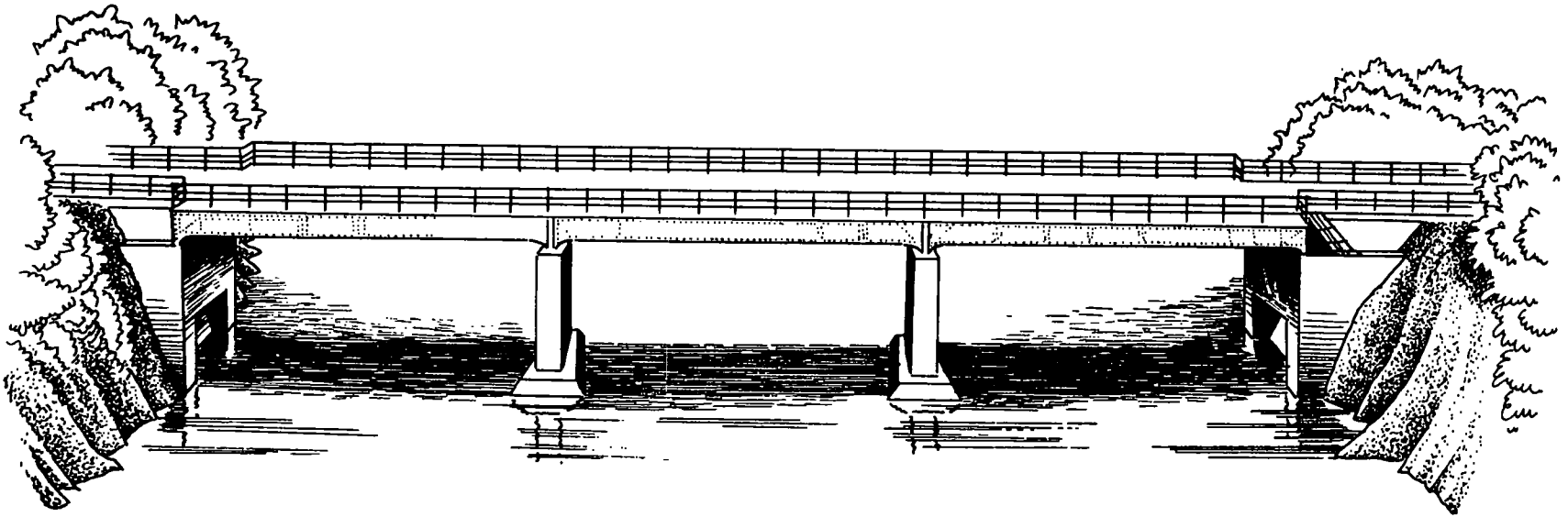


Figure 6-16. Steel deck plate girder bridge.

(3) *Steel arch.* Steel arch bridges may be of braced rib (trussed arch, fig. 6-17) or solid rib (plate girder arch; fig. 6-18) construction. Each is also found

in two subcategories: post supported traveled way and suspender supported traveled way.

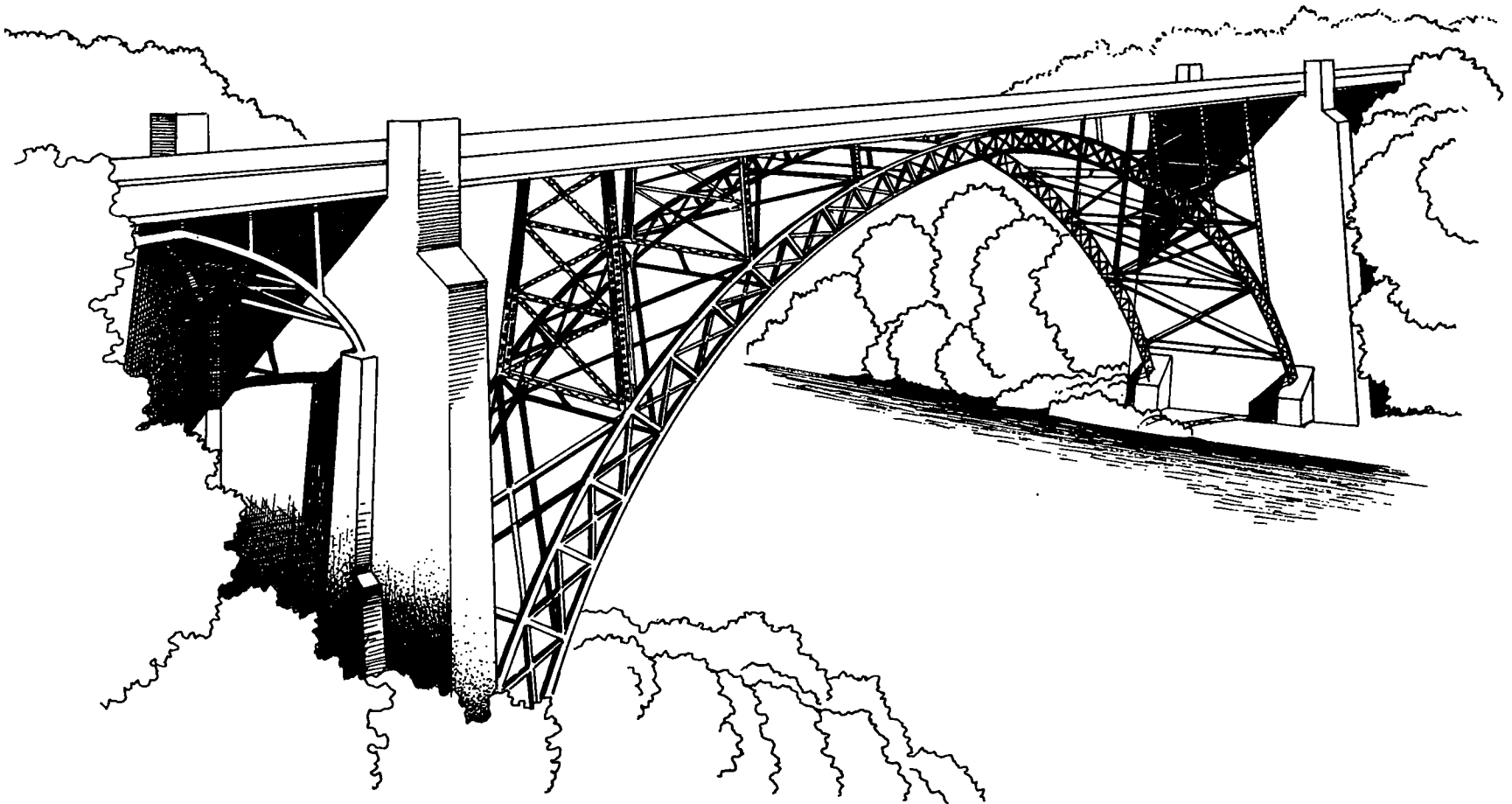


Figure 6-17. Steel braced rib arch bridge.

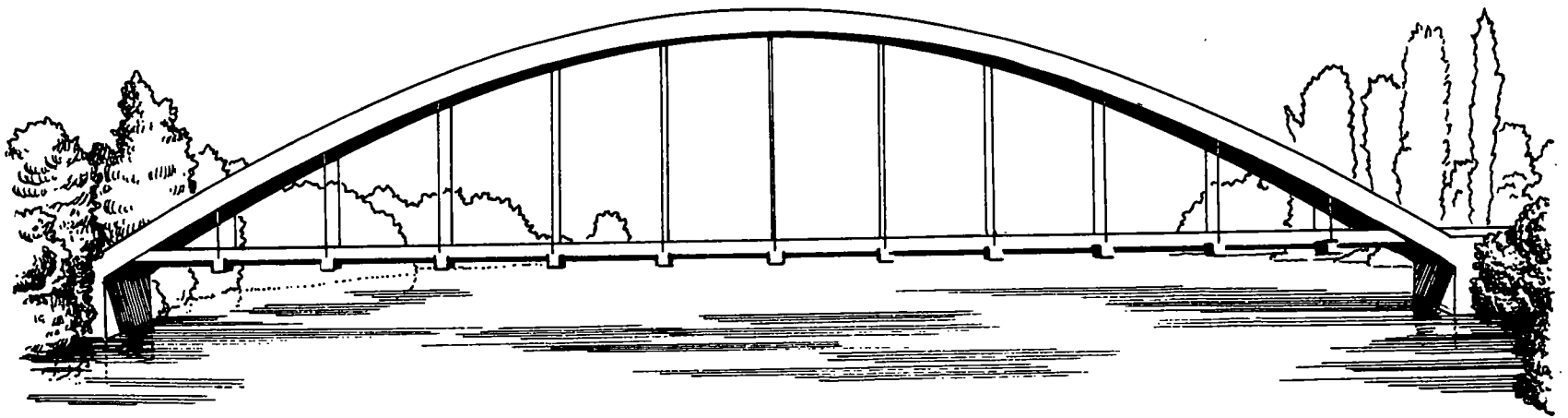
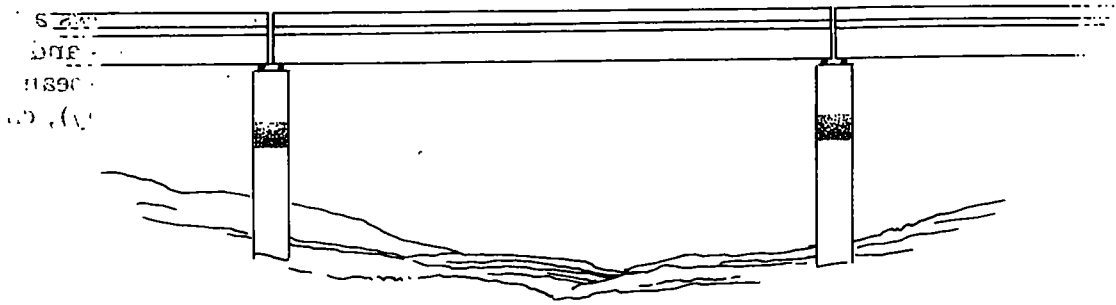


Figure 6-18. Steel solid rib arch bridge.

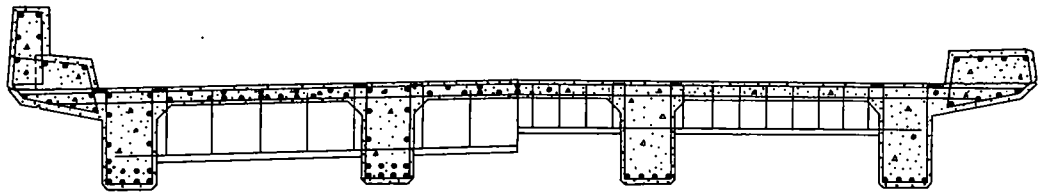
b. *Concrete Construction.*

- (1) *Contemporary design.* There are four basic types of modern concrete bridges. Each presents a similar appearance to the casual observer but may actually be either of simple or continuous span design. Moreover,

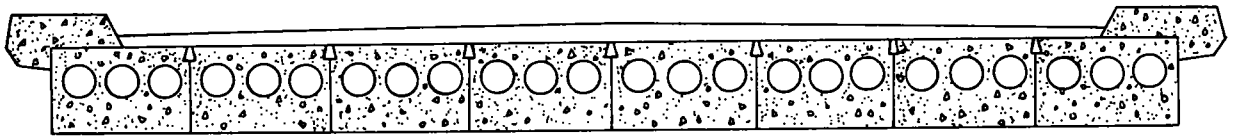
each may be built of either precast, prestressed materials, or may be cast in place. Figure 6-19 shows a typical side view of these bridges and a cross section of each type: I-beam, deck slab (for short spans only), channel section, and box girder.



a. Side Elevation



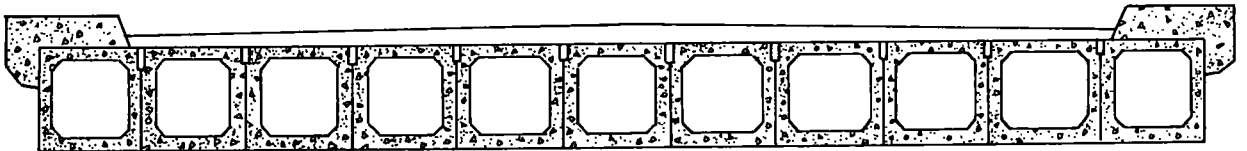
b. T-Beam



c. Deck Slab



d. Channel Section



e. Box Girder

Figure 6-19. Contemporary concrete bridge types.

(2) *Open spandrel arch* (fig. 6-20). This is a classic design which is still being followed. Some open spandrel mason-

ry arch bridges may be encountered, but they are not as common as concrete.

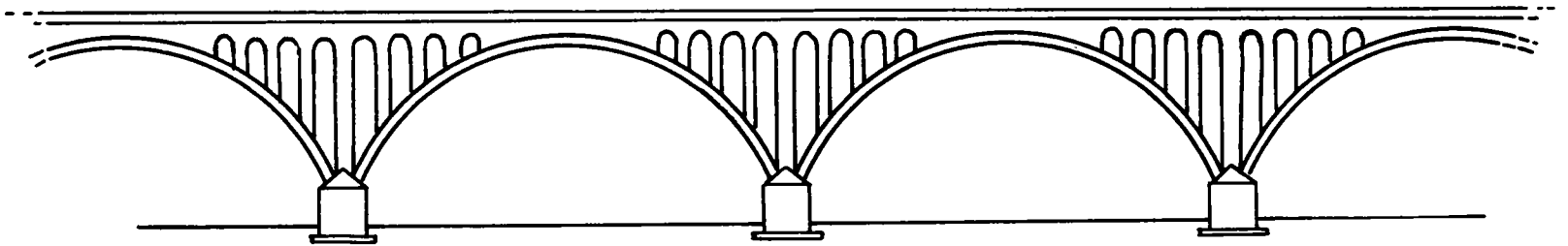


Figure 6-20. Open spandrel concrete arch bridge.

c. Massive Solid Arch. The solid arch bridge is one of the oldest bridge types in existence and may be constructed of either concrete or masonry (fig. 6-21). Many modern bridges that appear to be masonry solid arch, however, are in reality of steel or reinforced con-

crete construction with masonry veneer. Engineer route reconnaissance is often necessary to determine the construction technique employed. These bridges call for damage criteria and ADM placement for steel deck, plate girder, or contemporary concrete bridges.

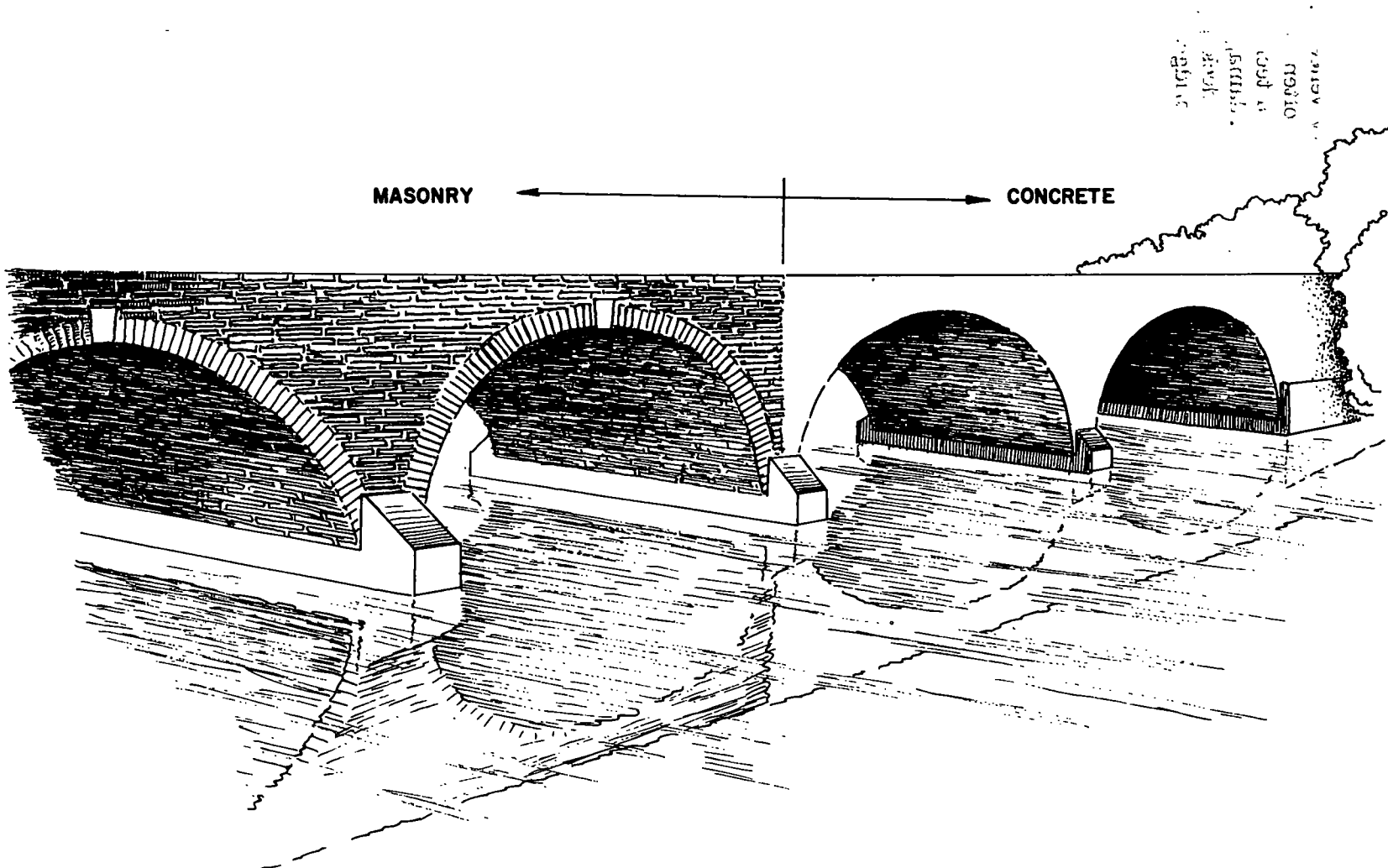


Figure 6-21. Masonry or concrete massive solid arch bridge.

6-17. Damage Criteria

a. To determine how ADM may be best used in bridge destruction, the most suitable effect of a nuclear detonation is selected, damage criteria are established, and the most suitable emplacement location for the ADM is chosen.

b. Most nuclear weapons employment methods consider airblast overpressure as the governing effect for bridge destruction. This text, however, with the exception of paragraph 6-22, considers blast solely as a bonus effect, and the cratering action of ADM is presented as the principal means of effecting bridge demolition.

6-18. Desired Damage

In bridge demolition, effective denial is achieved by the removal or destruction of a section of the traveled way. Three demolition alternatives according to time and manpower available for emplacement are provided to effect the collapse of at least one span. Table 6-1 presents a summary of damage criteria and emplacement locations for various bridge types correspondingly grouped by demolition option.

Table 6-1. Damage Criteria and Explosive Placement *

Bridge type	Abutment or pier face option		Abutment or pier top option		Traveled way option	
	Damage	Position	Damage	Position	Damage	Position
STEEL						
Through Truss	Pier or abutment and adjacent span(s) destroyed.	Face of pier or abutment behind abutment.	Top of pier or abutment plus adjacent span(s) destroyed; superstructure distorted.	Beneath traveled way on top of pier or abutment.	Traveled way breached. Superstructure distorted.	On traveled way over pier or abutment.
Deck Truss						
Through Plate Girder						
Deck Plate Girder						
CONCRETE						
T-Beam	Pier or abutment and adjacent span(s) destroyed.	Face of pier or abutment behind abutment.	Top of pier or abutment plus adjacent span(s) destroyed.	Beneath traveled way on top of pier or abutment.	Traveled way breached.	On traveled way over pier or abutment.
Deck Slab						
Channel Section						
Box Girder						
ARCH CONSTRUCTION						
Steel	Pier or abutment and adjacent span(s) destroyed.	Face of pier or abutment behind abutment.	Top of pier or abutment plus adjacent span(s) destroyed; arch rings breached.	Base of arch rings on top of pier.	Traveled way and arch rings breached.	On traveled way over arch.
Concrete						
Masonry						

* Pier destruction is considered the optimum damage criteria since it will achieve the collapse of two spans. In case of single span bridges or if pier destruction is for some reason impossible, then abutment demolition is considered the optimum criteria because of damage to approaches as well as collapse of one span.

a. Pier or Abutment Face Option. Destruction by ADM of a pier or abutment provides the best use of the cratering action of a nuclear detonation.

- (1) *Pier destruction.* Figure 6-22 illustrates the result of properly crater-

ing a bridge pier. This technique achieves maximum effectiveness in that two spans are collapsed, a pier is removed, and the river bottom is cratered at the point where a replacement pier must be built.

A black and white line drawing of a dam with a large breach. The dam is shown in cross-section, with a significant portion of its top and right side missing. Water is flowing over the remaining structure and through the gap. Debris is visible in the water downstream. The drawing is simple, using bold lines and hatching for shading.

Figure 6-22. Destruction of pier.

(2) *Abutment destruction.* In case of single span bridges or if pier demolition is not possible, destruction of an abutment is recommended. Figure 6-23 illustrates the effect of crater-

ing an abutment. Not only is the span collapsed, but a radiation hazard for a period following the detonation also results.

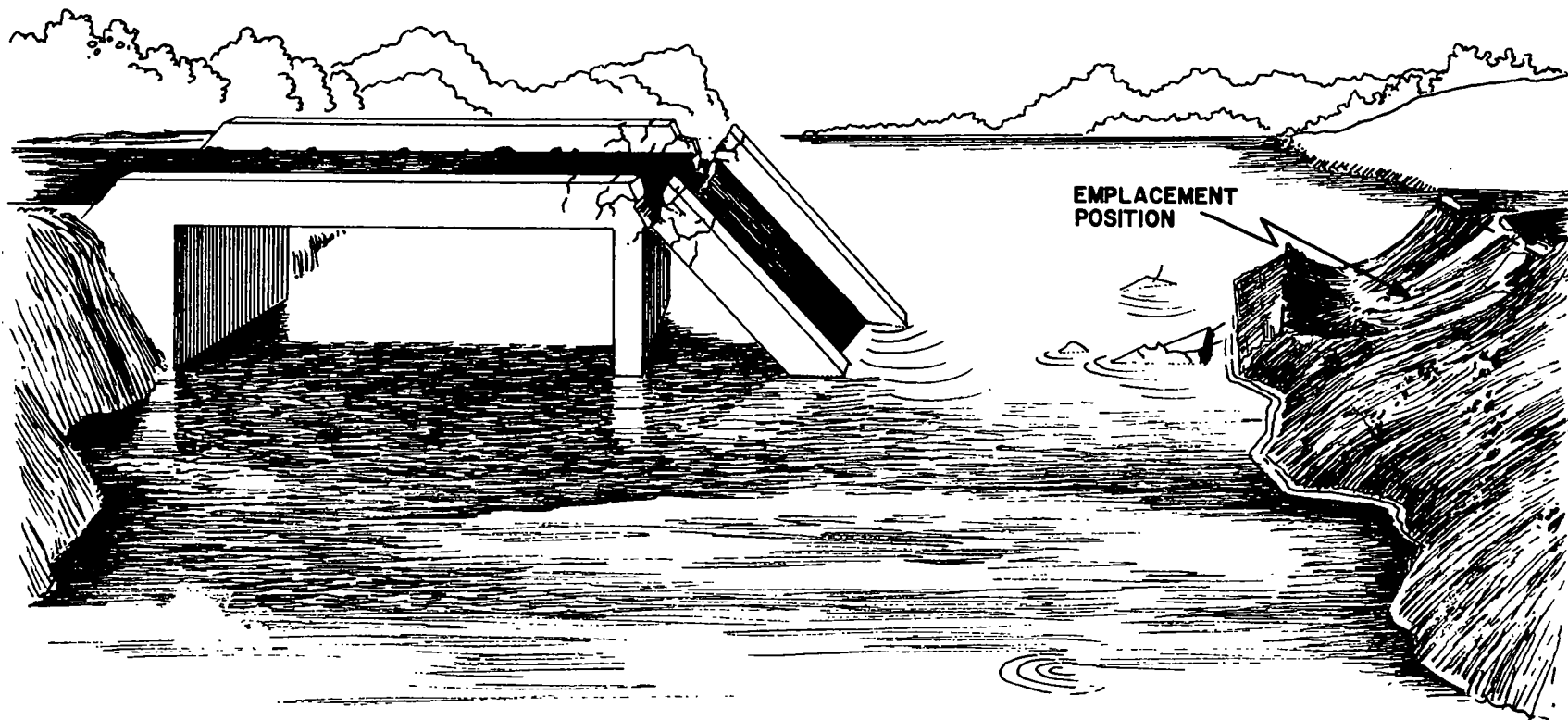


Figure 6-23. Destruction of abutment.

b. Abutment or Pier Top Option. When circumstances such as lack of equipment, manpower, or time do not permit placement of the ADM for pier or abutment destruction, the pier or abutment top option affords a means of exploiting cratering effects.

- (1) *Other than arch bridges.* In this case, the ADM is placed beneath the traveled way on top of the pier or abutment. If there is insufficient space between the bottom of the traveled way and the top of the pier, then placement on the face near the top is adequate. Figure 6-24 shows the results of such placement. Two spans are removed as well as the top portion of the pier. Unless the ADM was very close to the under side of the bridge floor, there will be little cratering action as far as the traveled

way is concerned, but there is considerable bonus blast damage to the supporting beams or girders.

- (2) *Arch bridges.* Whether constructed of steel, concrete, or masonry, the arch rings are the critical members of an arch bridge. Once the arch rings are breached, the span collapses. Recommended placement, therefore, is on top of a pier and at the base of one of the arch rings. If there are three rings, the center one usually provides the principal support, and the ADM is placed at its base. For single span bridges, placement is at the base of the ring where it adjoins the abutment. This placement also insures cratering of the top portion of the pier or abutment.

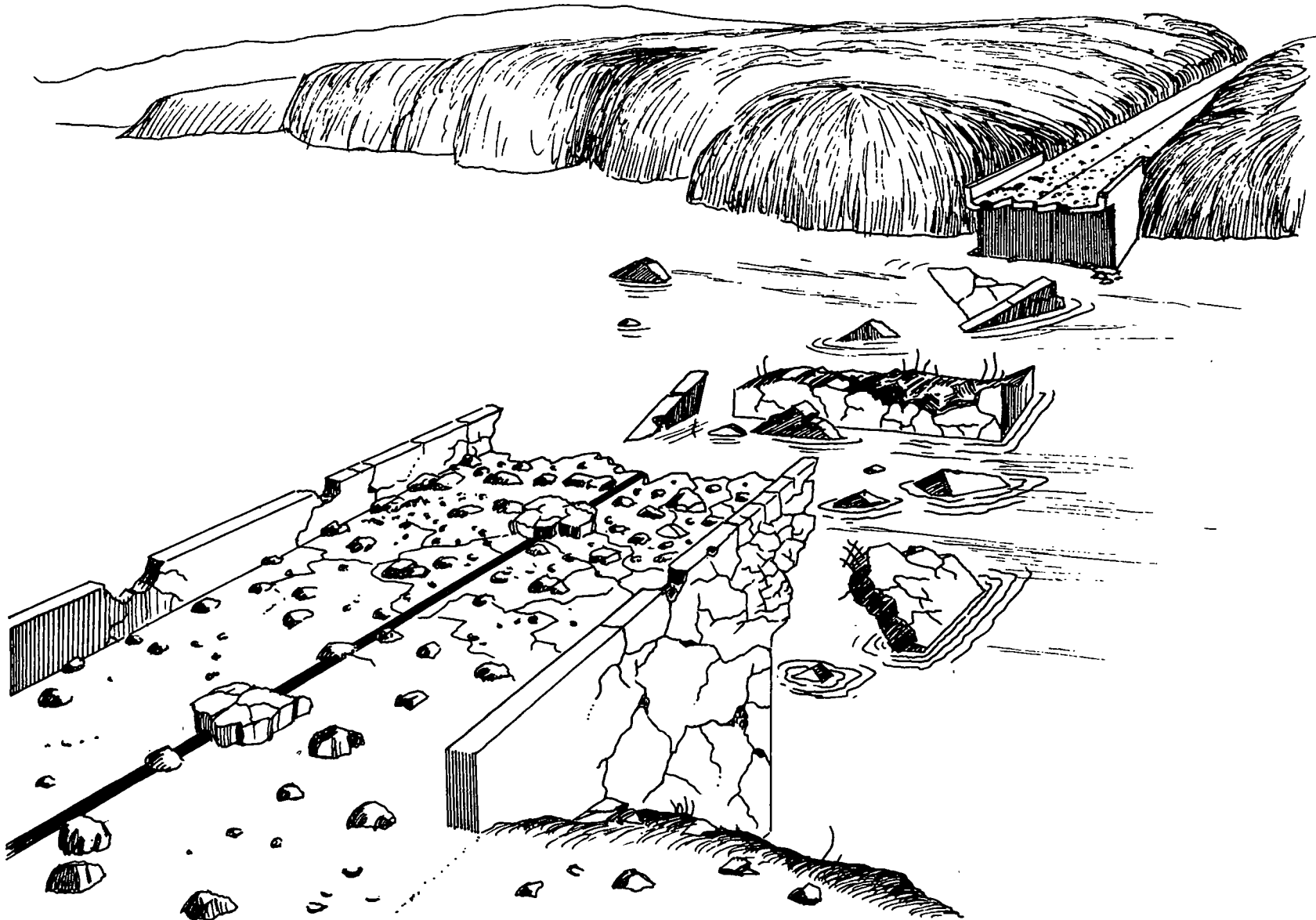


Figure 6-24. Destruction of pier top.

c. *Traveled Way Option.* With limited time available, the damage criteria recommended is complete breach of the traveled way. The ADM is placed directly on the traveled way and tamped with sandbags to enhance the cratering effect.

- (1) *Other than arch bridges.* For bridges of other than arch construction, placement on the traveled way is at a point over a pier or where the span joins the abutment if a single span

bridge. The cratering action breaches the traveled way and causes the spans to be torn loose from the substructure.

- (2) *Arch bridges.* In this case placement is over the center of the arch. This placement permits breaching of the arch ring(s) as well as the traveled way, resulting in collapse of the span. Figure 6-25 shows the results of such placement.

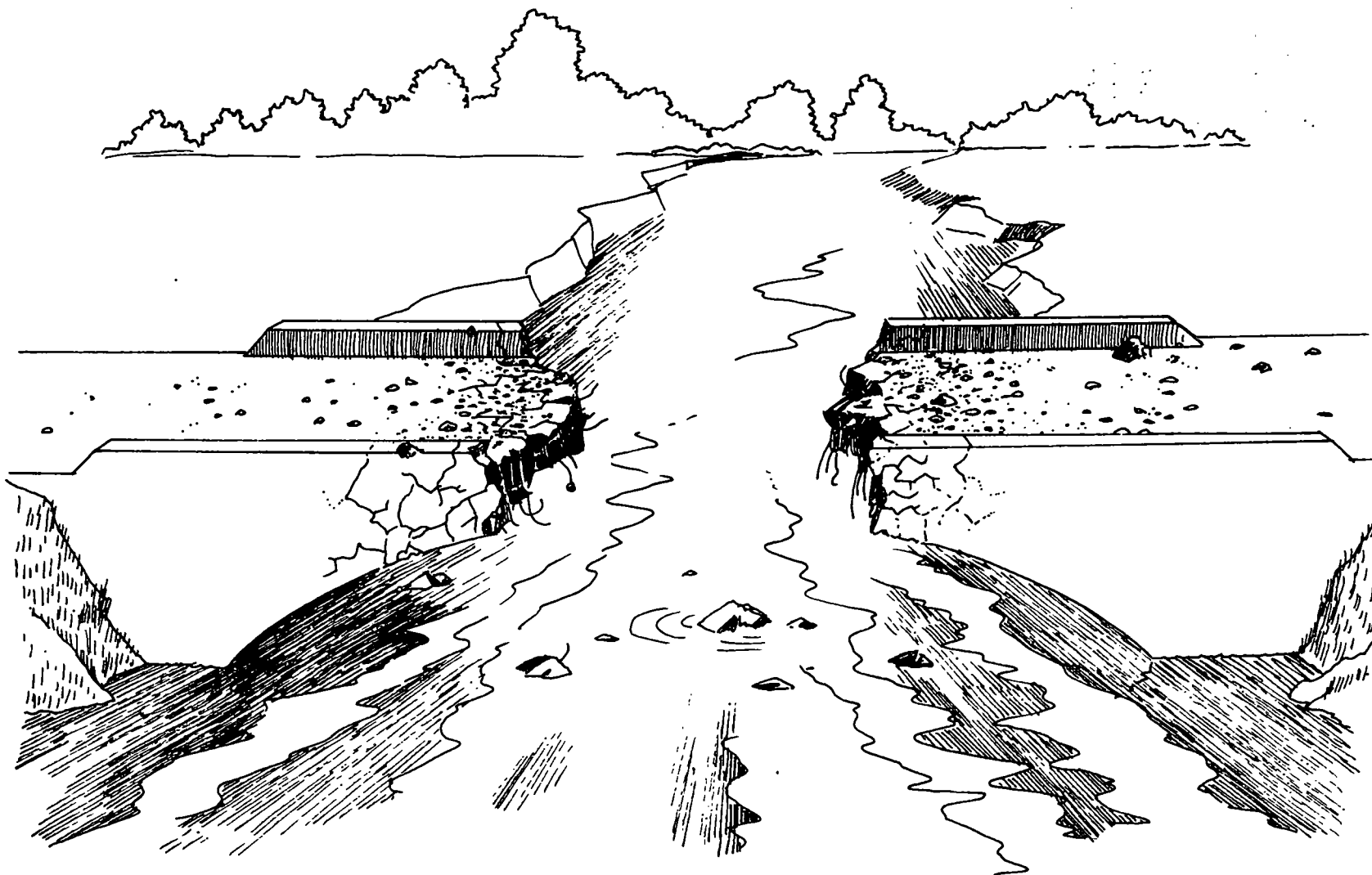


Figure 6-25. Destruction of traveled way.

6-19. Determination of Yield for Abutment and Pier Destruction

Since cratering is the process which achieves major bridge damage, it is necessary to relate crater dimensions to those of the critical bridge components. Determination of yield essentially involves measuring widths of traveled ways, piers, and abutments and ascertaining what yields produce crater dimensions of approximately equal measurements. It must be recognized, of course, that any plan for using ADM in demolition operations must include an evaluation of the bonus or limiting effects of the detonation such as airblast, ground shock, thermal, and nuclear radiation.

a. Demolition of Bridge Abutments.

(1) Emplacement behind abutment.

- (a)* The best ADM position for the demolition of a bridge abutment is behind the abutment buried at a depth equal to or greater than one-half of the height of the abutment as shown in figure 6-26. Detonation of the ADM at a depth equal to at least $\frac{1}{2} H$ insures that a significant portion of the abutment is destroyed.
- (b)* The yield requirements for ADM emplacement behind the abutment is determined by the width (B) of the abutment. Since the ADM is

buried at a depth of at least $\frac{1}{2} H$, the thickness of the abutment is always breached if a yield is used which is sufficient to produce a crater with a true crater diameter plus rupture zone equal to the width of the abutment. Figure 6-27 gives yield requirements for destroying bridge abutments by the detonation of ADM buried behind the abutment. The curves are based on the yield required to produce a true crater diameter plus rupture zone in hard rock equal to the abutment width (B) using the thickness of the abutment (T) as the effective depth of burst. The ADM yield required to destroy an abutment may be determined from figure 6-27 for the range of abutment dimensions given. For abutment thickness other than those for which curves are given, use the curve for the thickness which is *closest to but less than* the actual abutment thickness. The curves in figure 6-27 indicate that smaller yields are required as the abutment thickness increases. This is due to the enhancement of cratering effects as the depth of burial (thickness of abutment) increases.

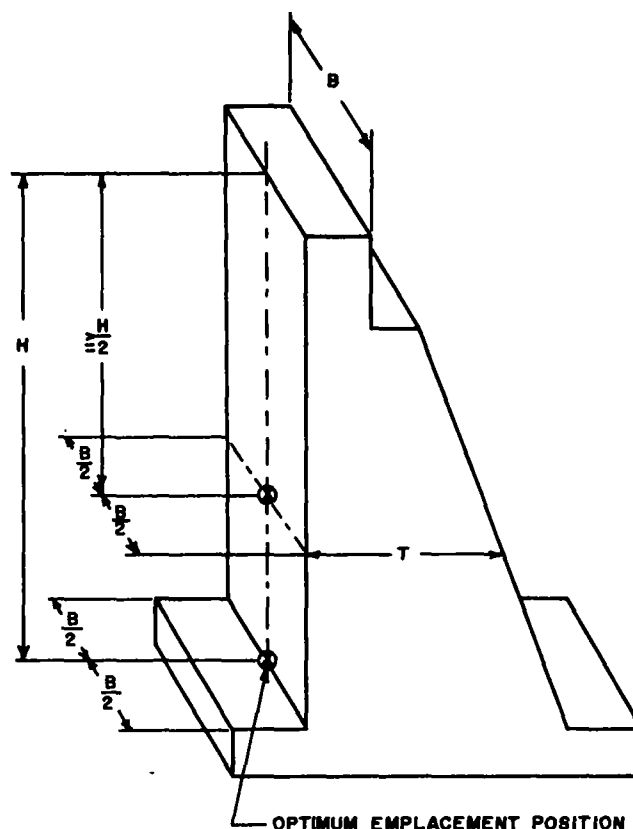


Figure 6-26. ADM emplacement behind bridge abutment.

(2) *Emplacement on face of abutment.*

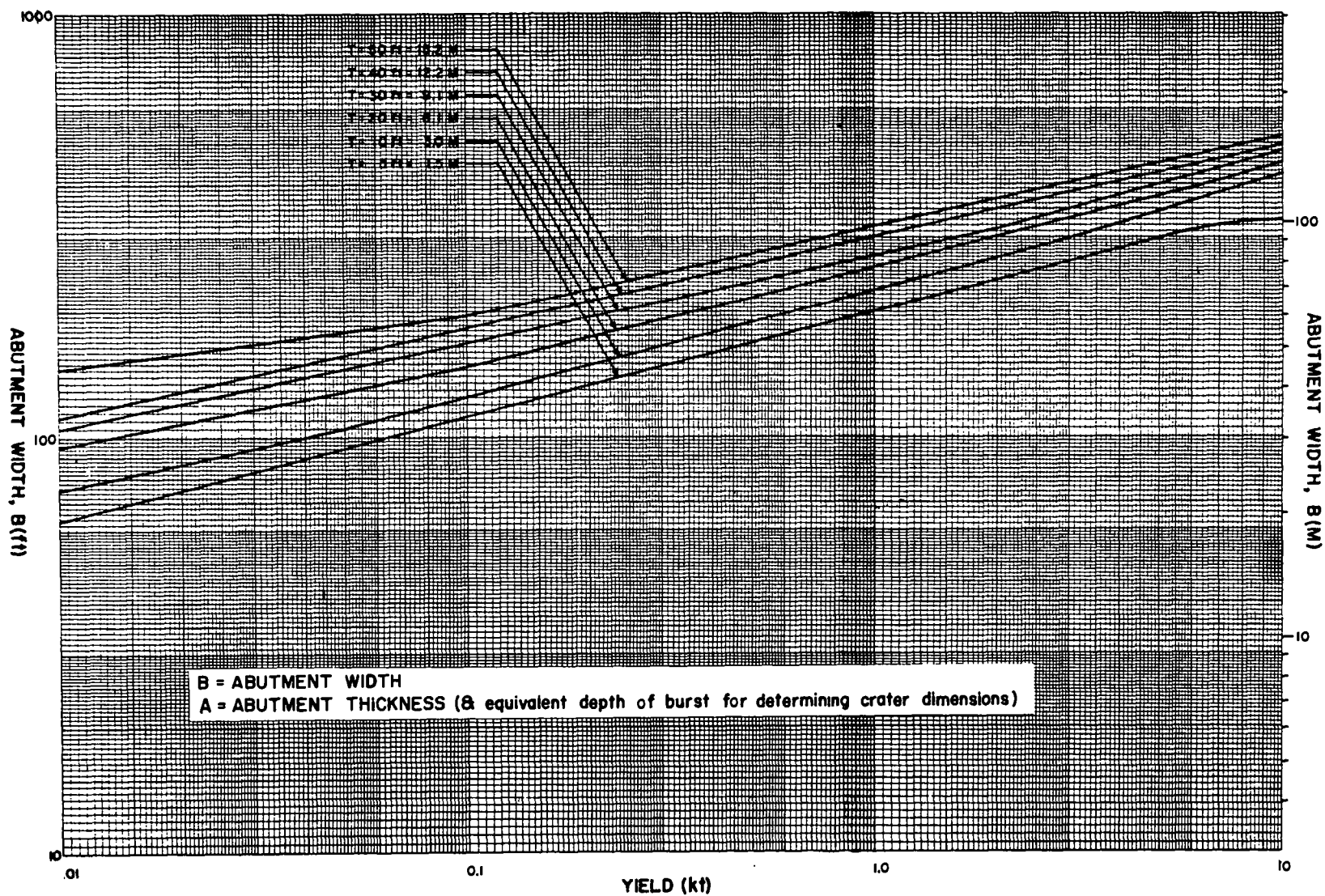
(a) If the characteristics of the ADM, the tactical situation, or the non-availability of emplacement construction equipment preclude placing the ADM behind the abutment, the nuclear explosive may be placed on the face of the abutment.

(b) The detonation of an ADM on the face of an abutment above the water level produces a crater in the abutment similar to the crater resulting from a surface burst in hard rock. If the ADM is placed underwater some increase in crater dimensions is achieved because of the tamping effect of the water, but no attempt is made in the yield selection criteria presented in this manual to numerically evaluate this increase.

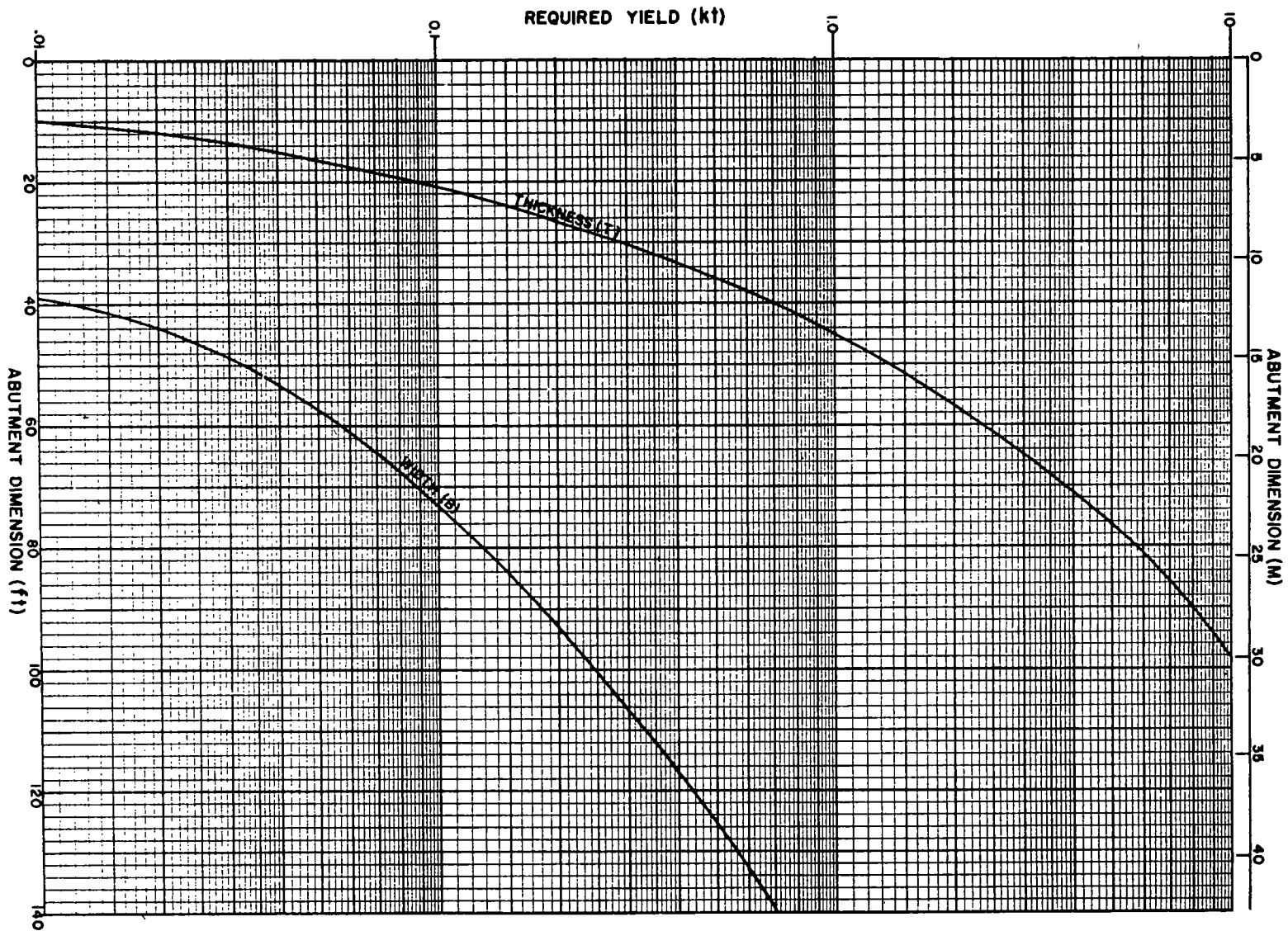
(c) The yield requirements for destruction of an abutment by detonation of an ADM

on the face of the abutment are determined by both the width (B) and the thickness (T) of the abutment. A yield should be selected which produces a true crater diameter plus rupture zone equal to the abutment width and a true depth ($45 W^{1/3}$ feet or $14 W^{1/3}$ meters) equal to the thickness. Figure 6-28 gives curves for determining required yields for abutment destruction. The higher yield determined from the curves for an abutment of given dimensions (B and T) governs.

(d) If an abutment has a demolition chamber (a chamber specifically incorporated by design to facilitate bridge denial), the ADM is detonated in the chamber. Figure 6-28 is used to select the required yield. The thickness of the abutment is considered to be the horizontal distance from the center of the ADM emplaced inside the chamber to the face of the wall adjacent to the backfill.



★Figure 6-27. Yield selection criteria for ADM burial behind abutment at depth equal to or greater than $1/2 H$.



★Figure 6-28. Yield selection criteria for ADM emplacement on face of abutment.



- (3) *Illustrative example.* The following example illustrates the recommended procedure for selecting yields required to destroy bridge abutments for various emplacement configurations:

Given: The bridge abutment shown in figure 6-29 is being considered for denial by ADM.

Find: The yield required to destroy the bridge abutment for the following emplacement positions: buried behind and at the base of the abutment; and emplaced on the face of the abutment at the base.

Solution:

Position 1—Yield Selection for Buried Emplacement Configuration.

Thickness of abutment at base =
 $T = 8$ feet.

Width of abutment = $B = 70$ feet.

Using figure 6-27 for $T = 5$ ($T = 8$, however, next lower curve is used) and $B = 70$, the minimum yield required is 0.015 kt.

Position 2—Yield Selection for Emplacement on Face of Abutment.

Using figure 6-28 for $T = 8$ feet, minimum yield required is less than 0.01 kt; and $B = 70$ feet, minimum yield required is 0.09 kt (governs).

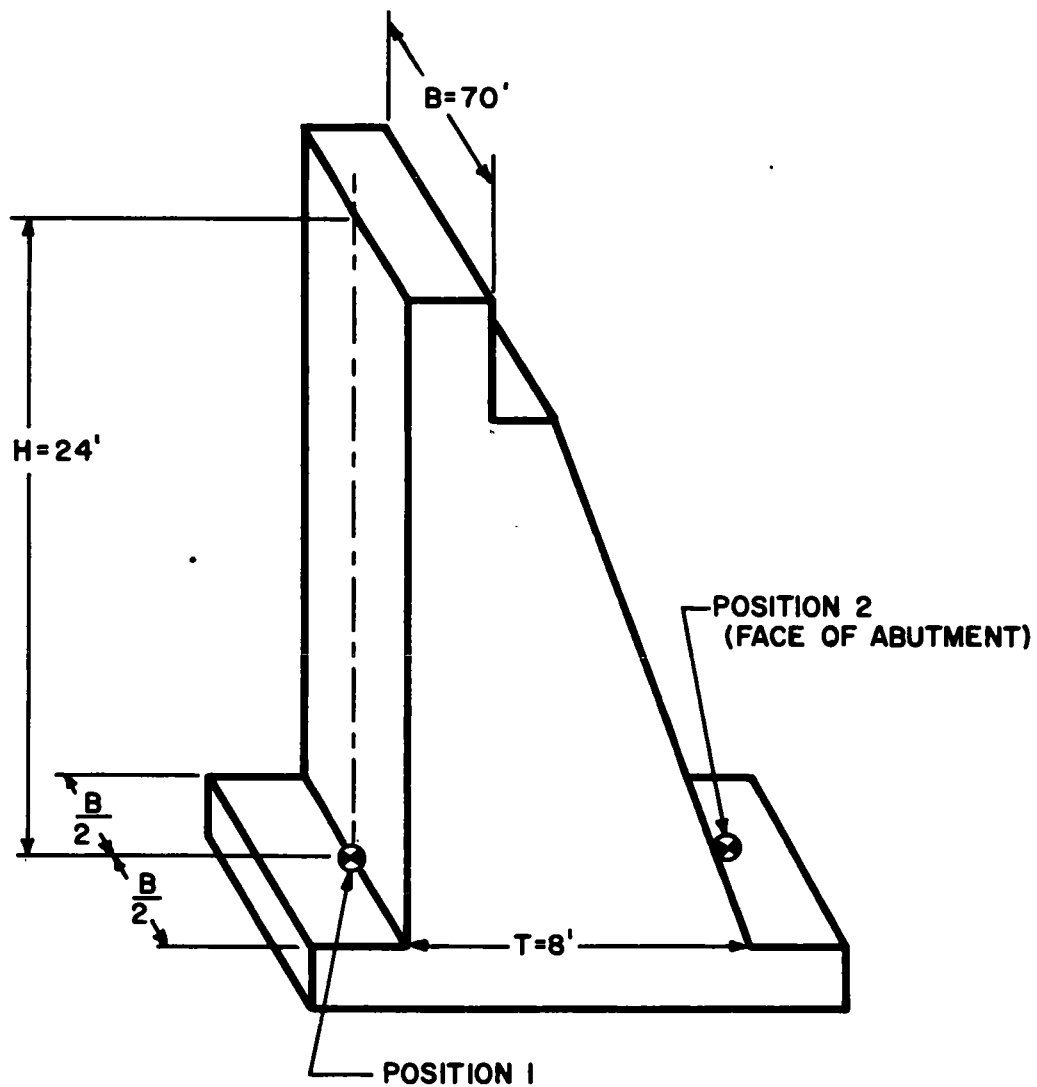


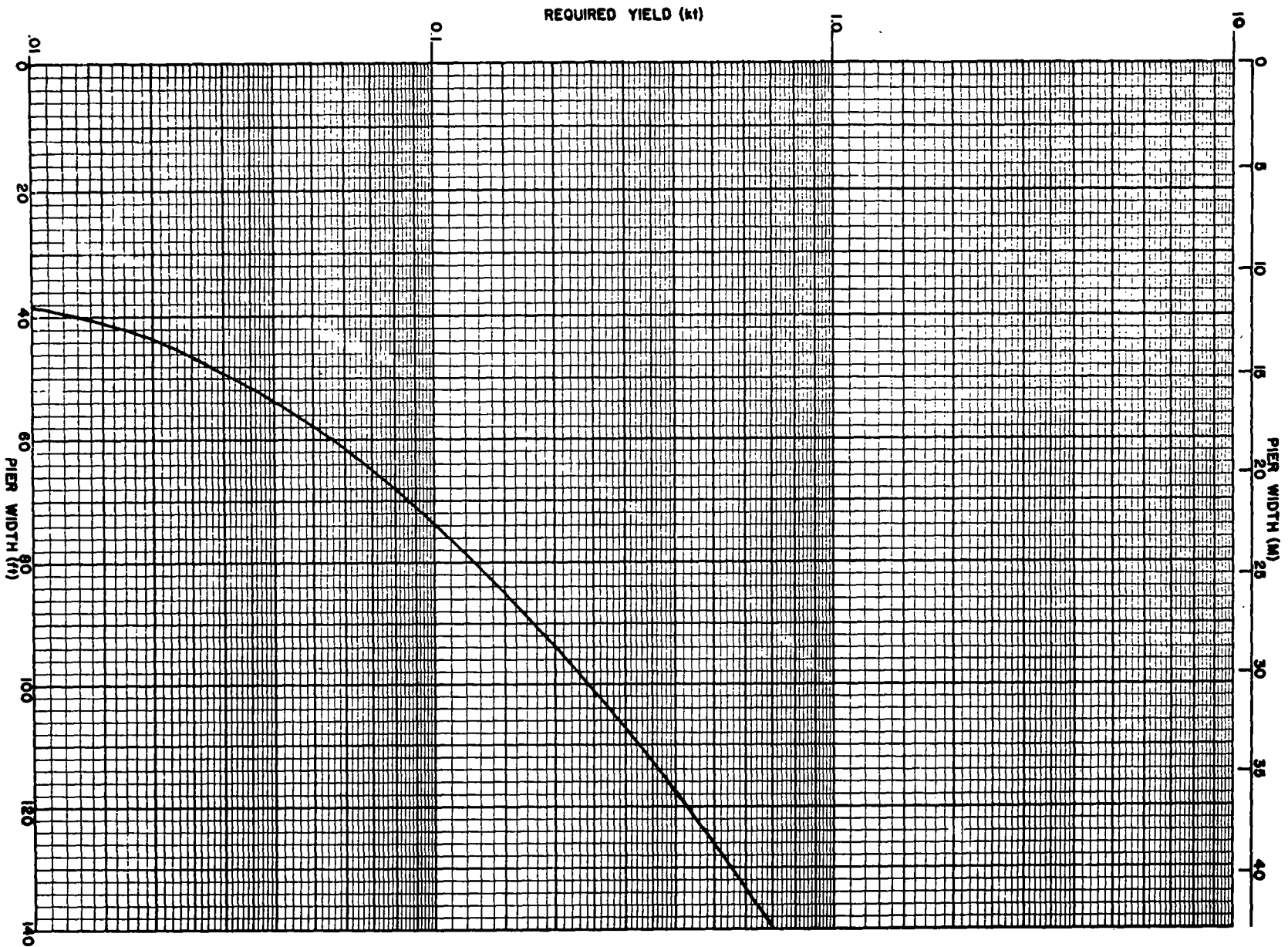
Figure 6-29. Illustrative example for destruction of bridge abutment.

b. Demolition of Bridge Pier.

(1) The best ADM emplacement position for pier demolition is at the base of the pier. If the device cannot be placed at the base of the pier, it is placed at a distance from the top of the pier—preferably one-half the pier height ($\frac{1}{2} H$)—to destroy a major portion of the pier.

(2) Selection of a yield to destroy a pier depends on the width (B) of the pier. The com-

bined effects of spall, vaporization, crushing, and plastic deformation will breach the pier thickness (T) if an ADM is used which is of sufficient yield to breach the width of the pier. Figure 6-30 gives the curve for determining the yield requirements for pier demolition. The curve is based on a determination of the yield which produces a true crater diameter plus rupture zone in hard rock equal to the width of the pier.



★Figure 6-30. Yield selection criteria for ADM emplacement on face of pier; top of pier or abutment; or traveled way.

6-20. Determination of Yield for Pier Top Destruction

The pier top option is recommended when the abutment or pier face option cannot be accomplished. Figure 6-31 illustrates placement under traveled way on top of a pier or abutment. Figure 6-32 shows placement at

base of arch rings on either top of pier or on abutment shelf. For any of these situations, yield determination corresponds to width of the pier or abutment. To determine yield, enter figure 6-30 with the pier or abutment width (B), read up to width curve, and over to yield.

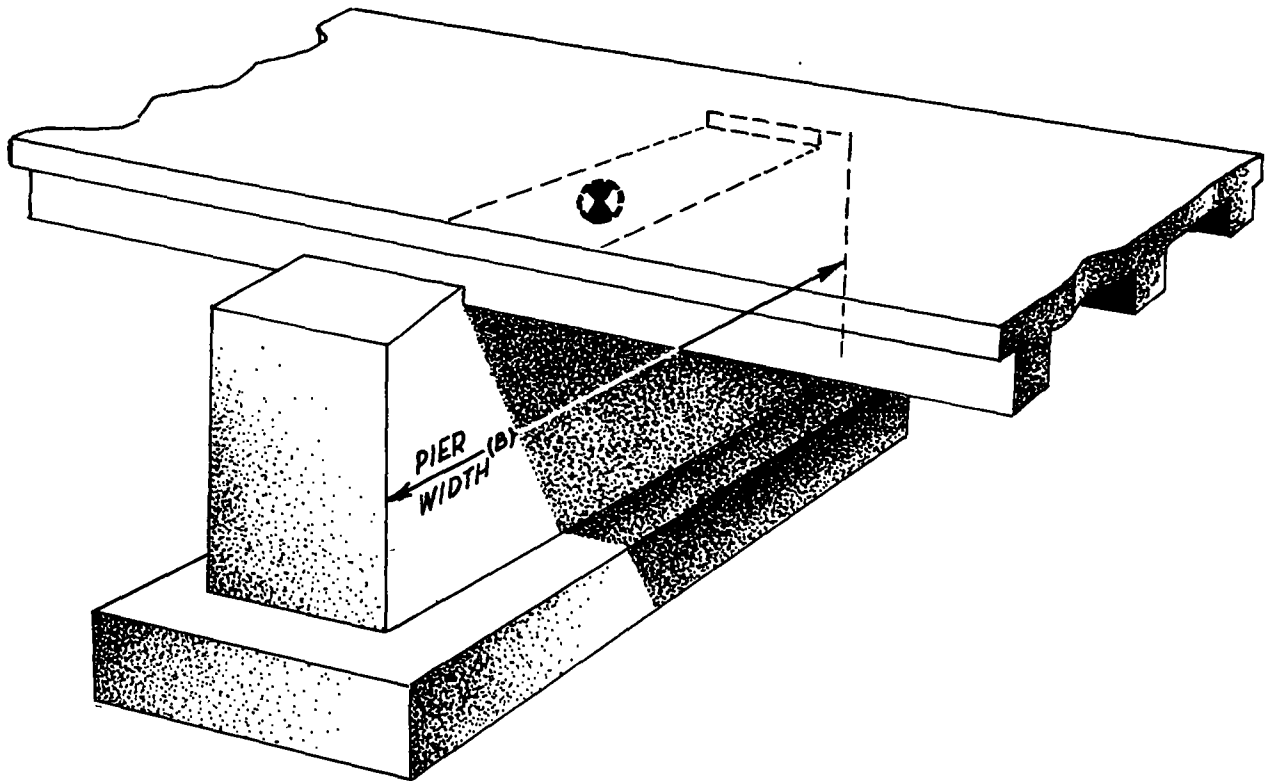


Figure 6-31. Dimensions of concern for placement under traveled way on top of pier.

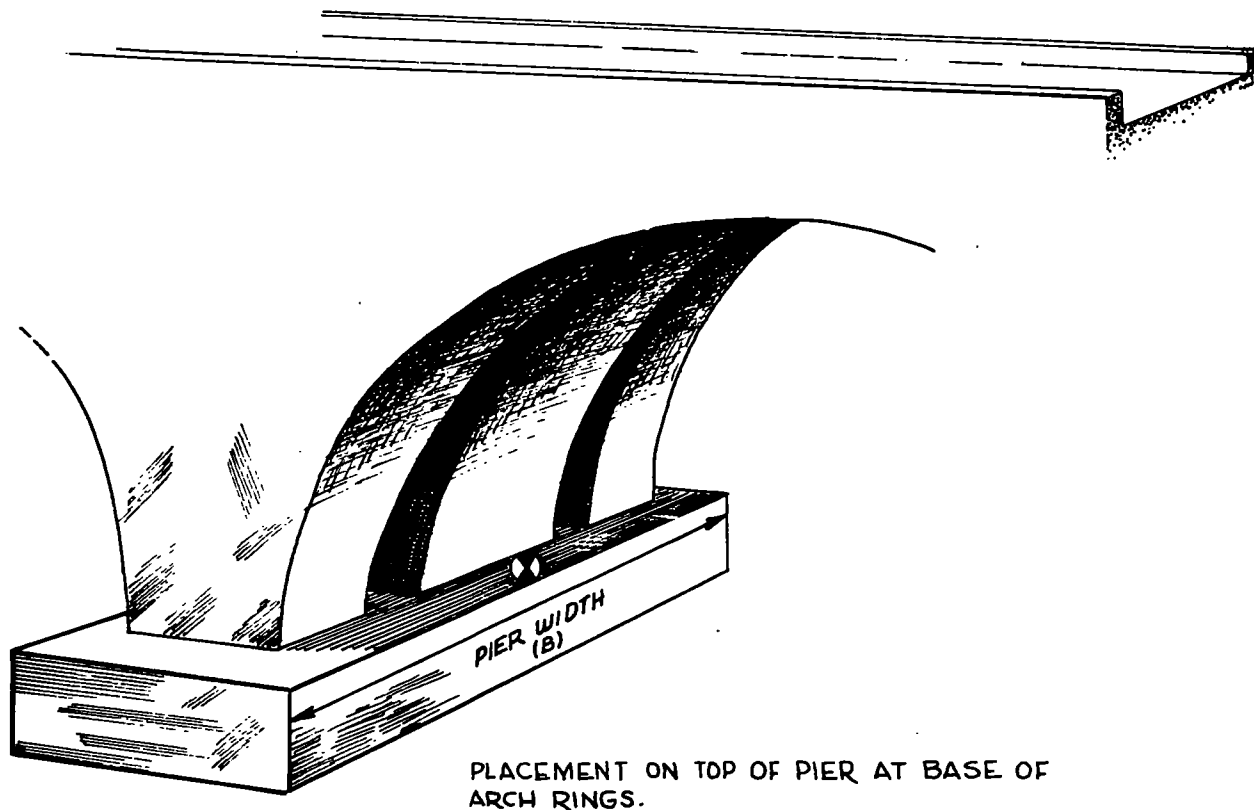


Figure 6-32. Dimensions of concern for placement at base of arch rings.

6-21. Determination of Yield for Traveled Way Destruction

Figures 6-33, 6-34, and 6-35 illustrate the traveled way option emplacement method. There are three cases: placement over pier (fig. 6-33); over abutment (fig. 6-34); or over

arch (fig. 6-35). In all cases, the traveled way width (B) is the dimension of primary concern. Yield determination is made by entering figure 6-30 with traveled way width (B), reading up to width curve, and over to yield.

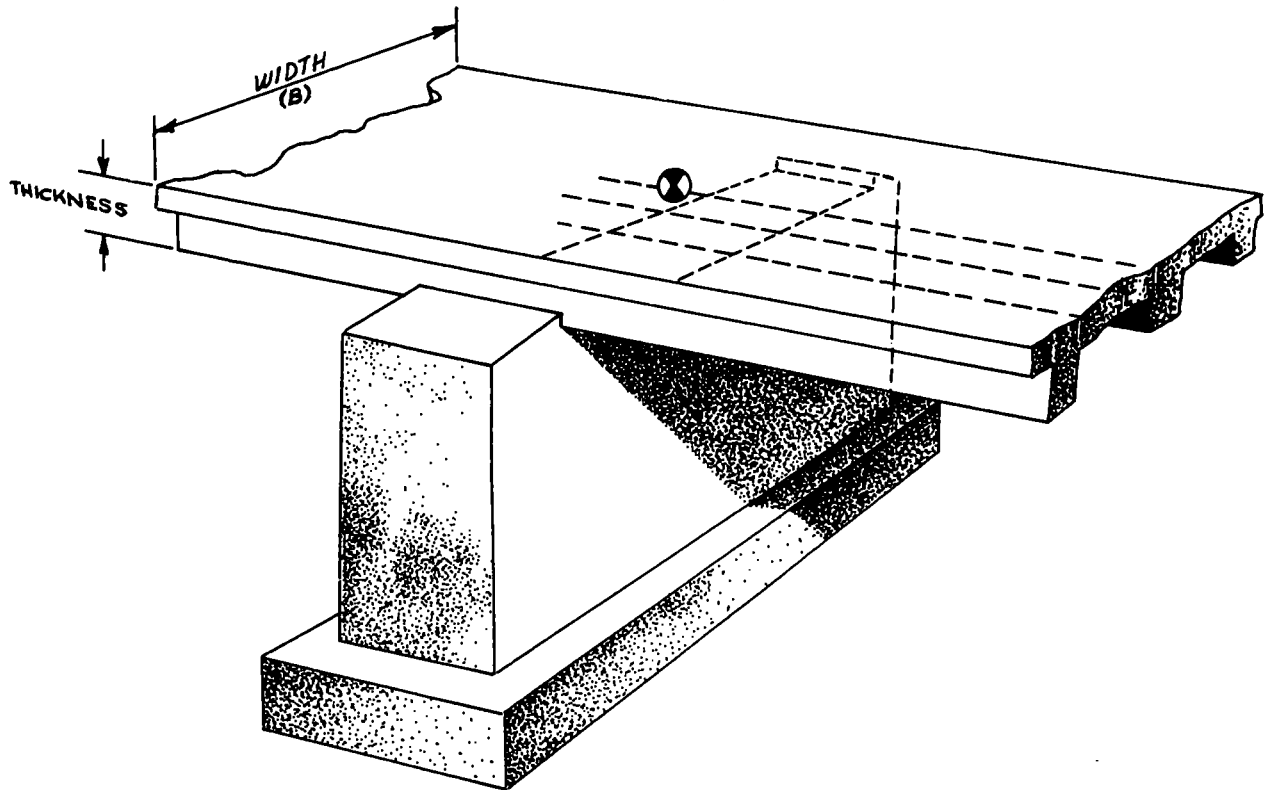


Figure 6-33. Dimensions of concern for placement on traveled way over pier.

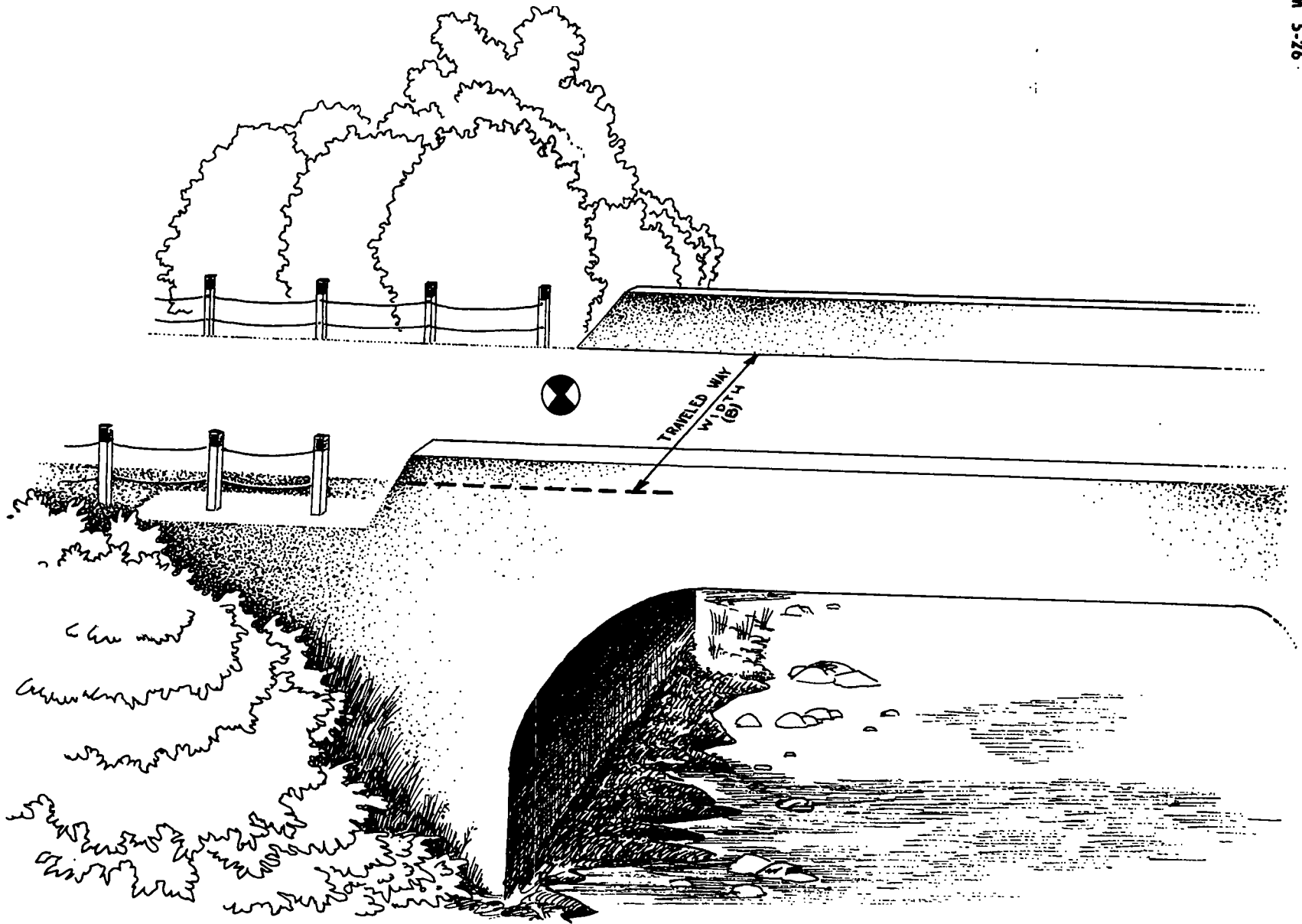


Figure 6-34. Dimensions of concern for placement on traveled way over abutment.

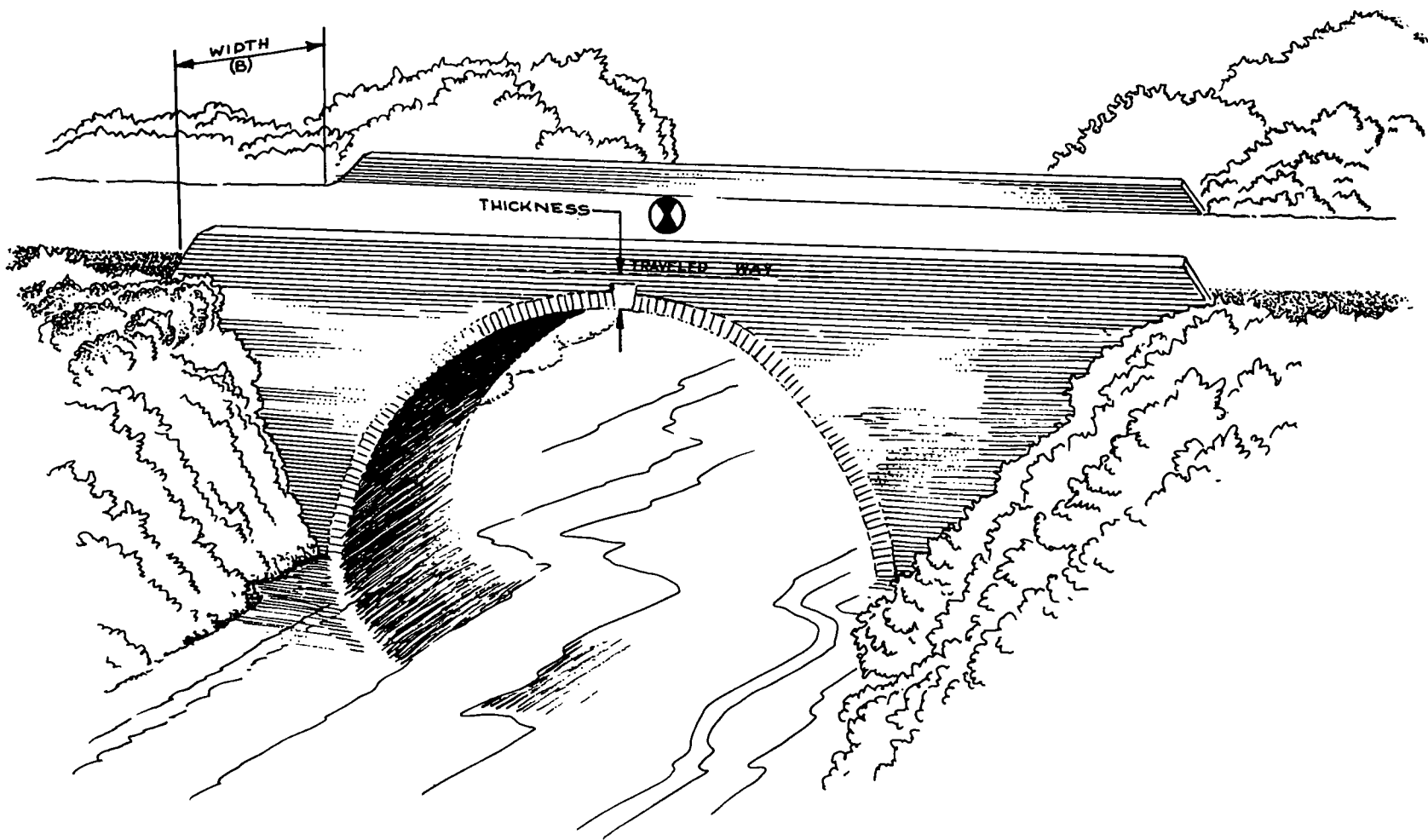


Figure 6-35. Dimensions of concern for placement on traveled way over arch.

6-22. Blast Criteria for Bridge Destruction

In addition to the cratering effect, steel truss and floating bridges are particularly vulnerable to destruction by the blast effects of ADM. When it is desired to take advantage

of the blast effect, the ADM is positioned so that upon detonation the blast wave impacts side on to the bridge. Radius of damage for blast effects to steel truss and floating bridges are given in appendix II and FM 101-31-2.

Section IV. DAMS

6-23. General

a. The development of ADM has provided a capability for readily destroying large dams; one nuclear detonation can accomplish what could not have been done previously by hundreds of tons of TNT. In addition, the destruction potential of ADM are enhanced by the sudden release of large quantities of water below the dam.

b. Damage to power production equipment, turbines, and similar facilities are usually best accomplished by conventional explosives and, therefore, are not discussed in this manual. If these facilities are considered appropriate for destruction by ADM, blast criteria for industrial equipment and buildings are applicable. (See app. II and FM 101-31-2.)

c. Dams may be categorized in four general types: gravity, arch, buttress, and earthfill. The characteristics of each type present different methods of demolition to achieve an effective breach. It is essential, therefore, that the target analyst recognize basic dam types in order to obtain the best results from ADM employment.

d. The yields to be obtained from the curves that have been included in this section are for a single breach. If the purpose of breaching is to create a large flood, it may be necessary to burst two or more ADM simultaneously to remove instantaneously a large portion of the structure (fig. 6-36). Paragraph 6-30 discusses the hydrological aspects and the probabilities of downstream flood damage.

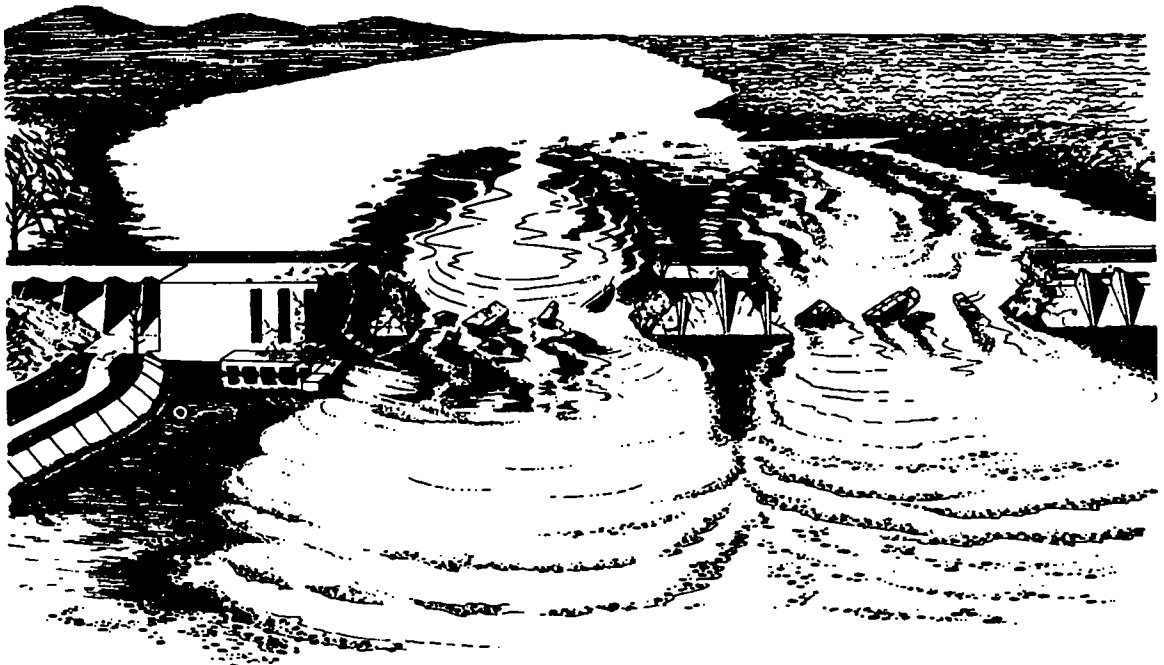
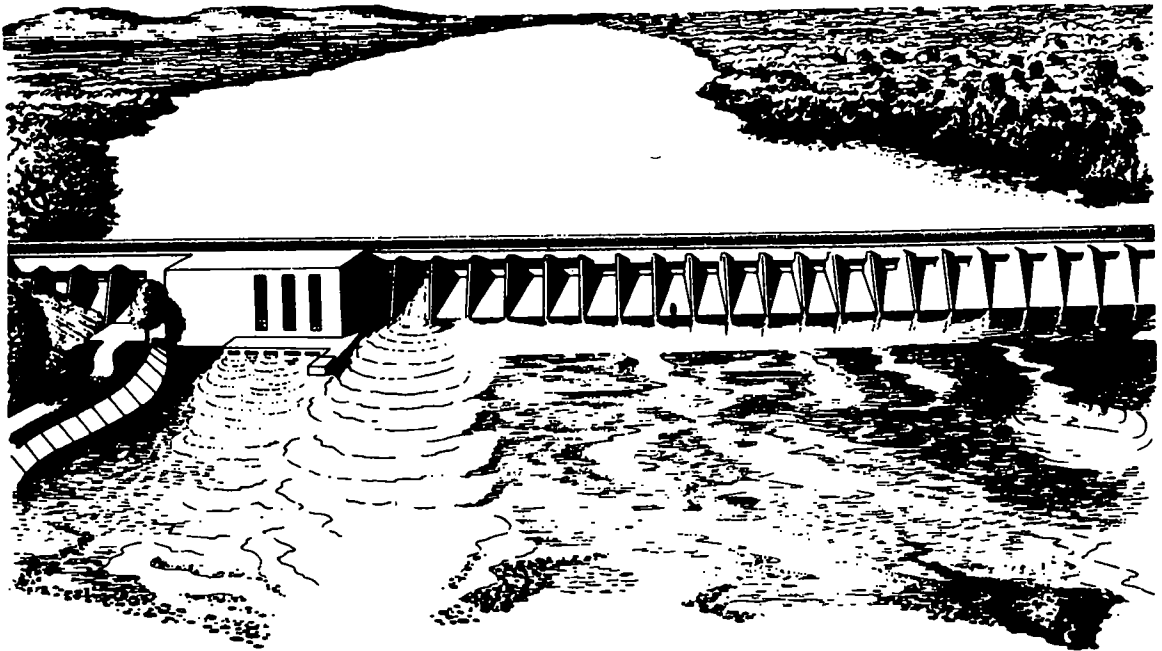


Figure 6-36. Before and after views of a gravity dam subjected to multiple nuclear explosions.

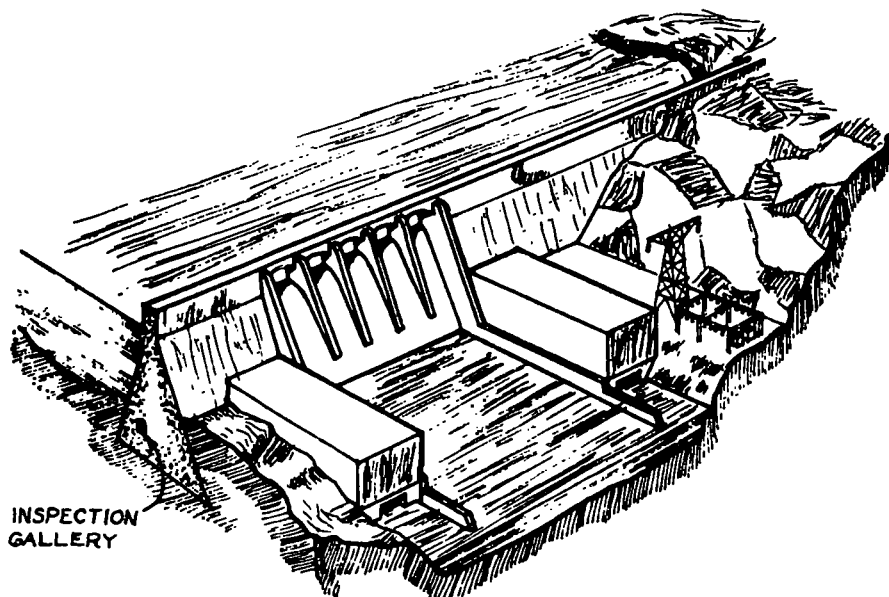


Figure 6-37. Gravity dam.

6-24. Gravity Dams

a. Gravity dams (fig. 6-37) constructed of concrete or masonry have massive cross sections and often rise to heights of 400 feet or more. Because of the volume of material to be shattered, gravity dams are best breached by placement of the ADM in an inspection gallery. If more than one gallery exists, the one which is lowest and nearest to the upstream heel of the structure is selected.

b. A method for determining the yield required to breach a gravity dam is presented for the following emplacement locations (fig. 6-38):

- (1) In an inspection gallery.
- (2) On the upstream face of the dam at a water depth at least twice the distance to be breached or 50 feet (15 meters), whichever is the smaller, to insure efficient coupling of the energy from the ADM into the concrete.
- (3) On the downstream face of the dam below the water level.

c. Yield selection curves for breaching concrete gravity dams are given in figure 6-39. The yield selection criteria are based on breaching the distance to the downstream face

primarily by the spall mechanism and breaching the distance to the upstream face by the cavity and rupture zone formed around the ADM. If the ADM is emplaced in an inspection gallery (position 1), the yields required for breaching the distance to the *upstream face* should be determined separately by using the appropriate curves in figure 6-39 (curves a and b); the *larger* of the two breaching yields is the governing yield for demolition of the dam. If the ADM is placed on the upstream face (position 2), it is only necessary to determine the yield required to breach the distance to the downstream face (curve a). If, on the other hand, the ADM is placed on the downstream face (position 3), it is only necessary to determine the yield required to breach the distance to the upstream face (curve c).

★d. *Illustrative Example.* The following example illustrates the procedure for selecting yields required to destroy concrete gravity dams for various emplacement locations.

Given: One of several strategic targets being considered for destruction is the dam shown in figure 6-40 with dimensions as indicated.

Find: The ADM yield required to breach the

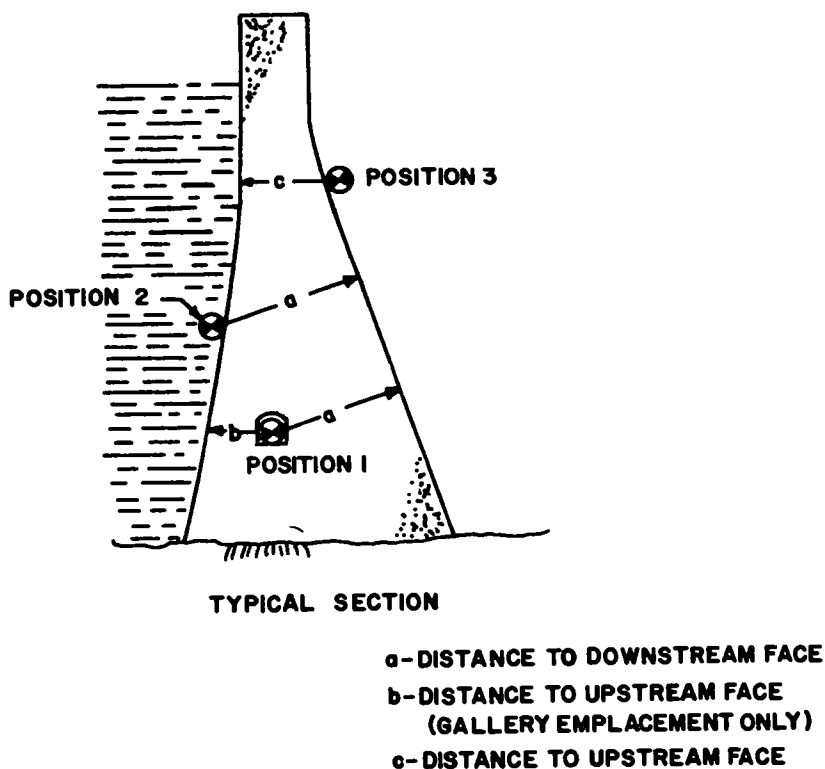


Figure 6-38. ADM emplacement for concrete gravity dam demolition.

dam for the following emplacement positions: the inspection gallery; on the upstream face, 50 feet below the water level; and on the downstream face, 100 feet below the top of the dam.

Solution: Position 1—Emplacement in Inspection Gallery. The distance to the upstream face of the dam is 50 feet and to the downstream face of the dam is 85 feet. Referring to figure 6-39 for the distance to the upstream face (curve b), the yield required is 0.05 kt; and for the distance to the downstream face (curve a), the yield required is 0.08 kt.

Answer: Yield required to breach the distance from inspection gallery to downstream face of dam is the critical (larger) yield, and the ADM to be used must be equal to or greater than 0.08 kt.

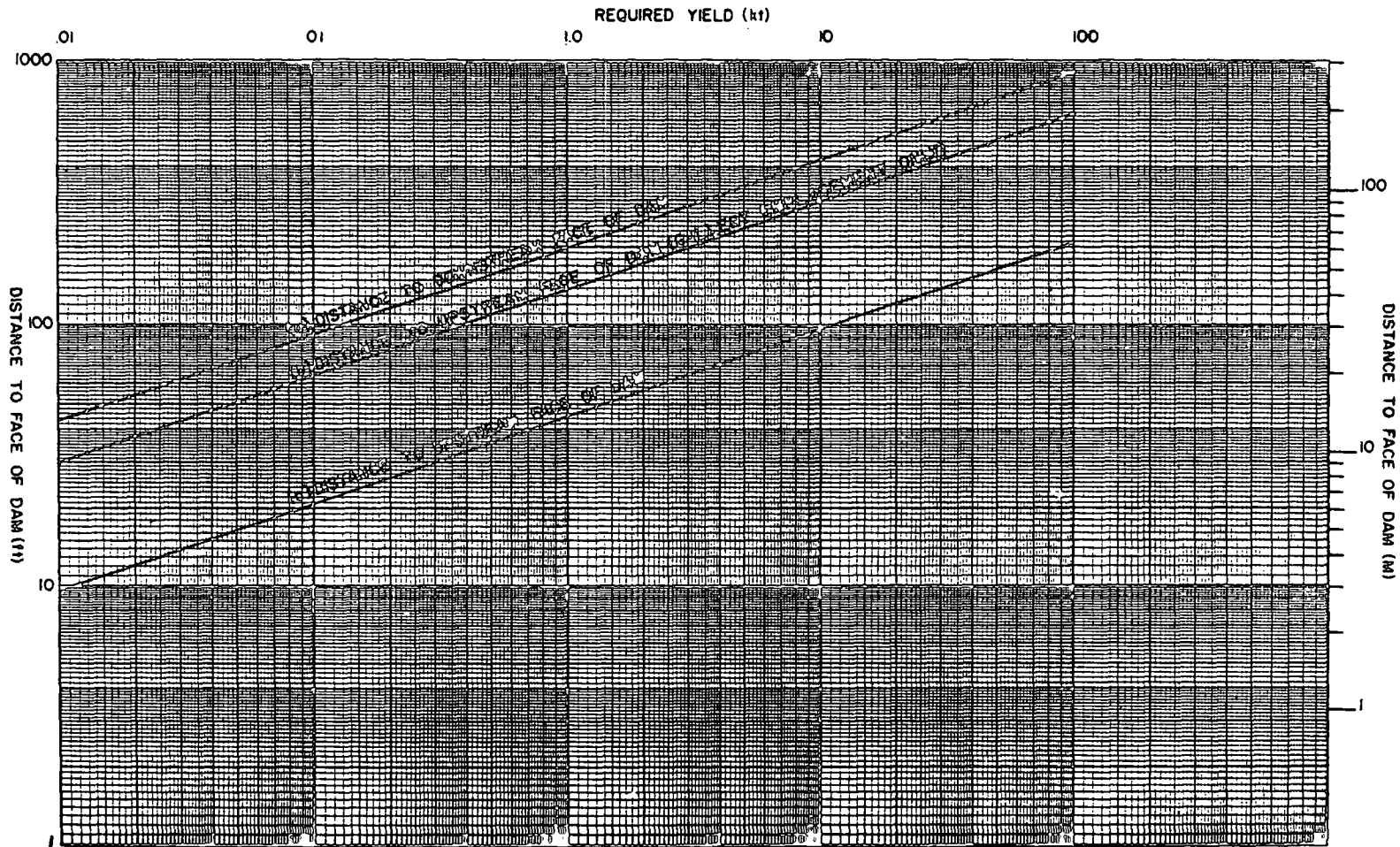
Position 2—Emplacement on Upstream Face

of Dam. The ADM is emplaced on the upstream face 50 feet below the reservoir water level or 100 feet from the top of the dam as shown. With the device in this position, the distance to the downstream face is 60 feet. Referring to figure 6-39 (curve a), the required yield is 0.026 kt.

Answer: ADM yield to be used must be equal to or greater than 0.026 kt.

Position 3—Emplacement on Downstream Face of Dam. The ADM is placed on downstream face of dam, 50 feet below the water level or 100 feet below top of dam as shown. With the ADM in this position, the distance to the upstream face is 66 feet. Referring to figure 6-39 (curve c), the required yield is 3.2 kt.

Answer: ADM yield to be used must be equal to or greater than 3.2 kt.



☆Figure 6-39. Yield selection criteria for concrete dam demolition.

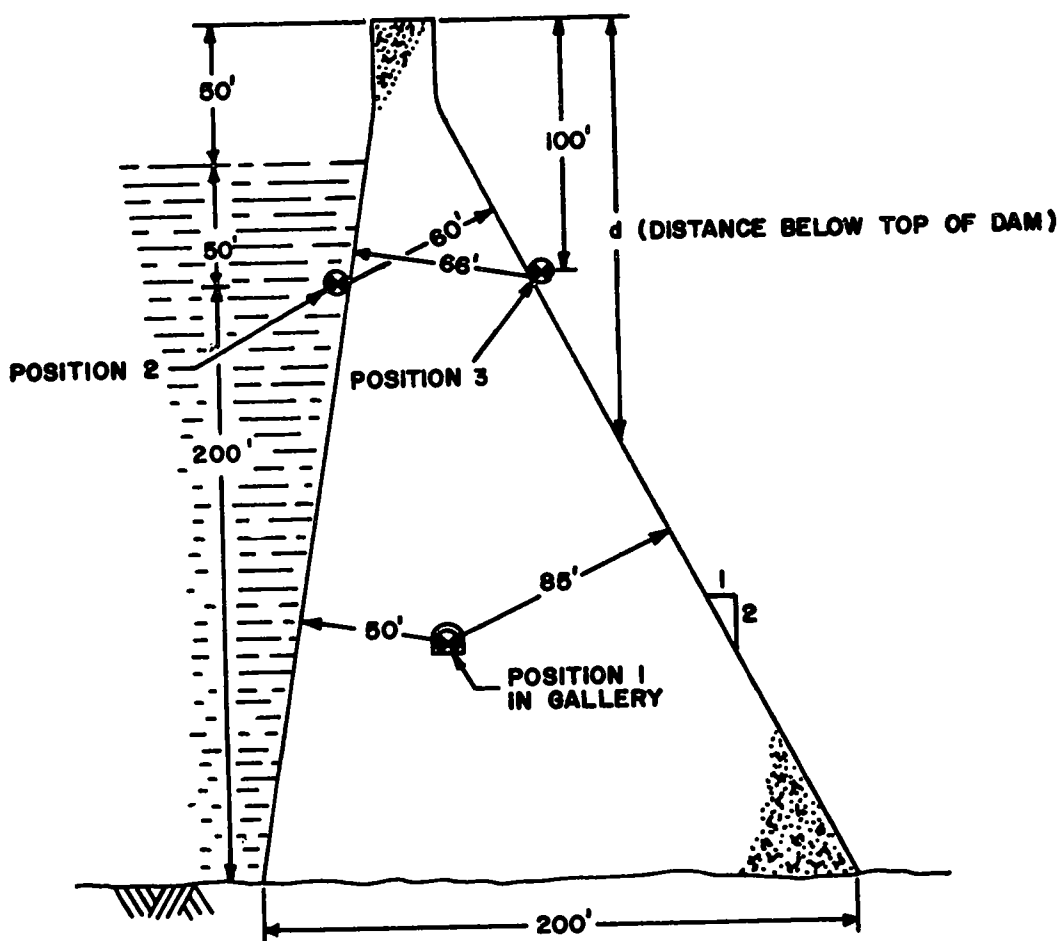


Figure 6-40. Concrete gravity dam for illustrative example.

6-25. Arch Dams

a. *Arch dams* (fig. 6-41) usually are thin, relatively short, and comparatively high. They are constructed of masonry or concrete usually in V-shaped gorges. The thinness of the cross section allows a smaller yield ADM to be used than is required for the more massive gravity dams. The inspection gallery inside the structure is again the best site for the placement of an ADM; however, the galleries may not be easily accessible, and smaller dams may have no galleries at all. Placement in the reservoir on the upstream face of the structure at least 50 feet (15 meters) below the water level also produces excellent results in such instances. Because of the thin cross section, even place-

ment of an ADM on the downstream face of the structure generally gives satisfactory results with relatively small yields. Furthermore, the stability of an arch dam is dependent upon the arch abutments; for this reason, the dam is also vulnerable to collapse from demolition of its abutments.

b. Figure 6-39 is used to compute the required yield for breach of an arch dam. The computation is accomplished in the same manner as described for gravity dams in paragraph 6-24.

c. The strength of this type dam lies in its arch construction. Any appreciable weakening of the arch permits the hydrostatic pressure

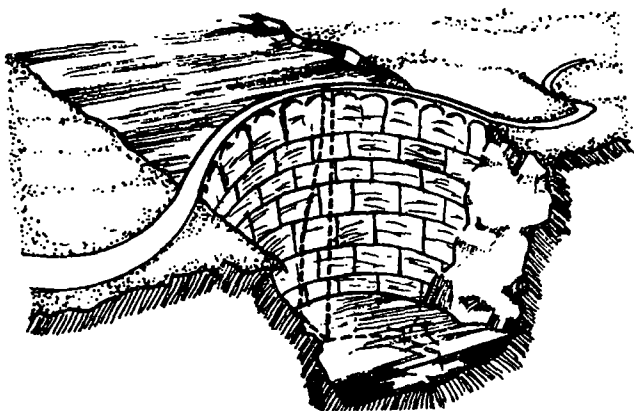


Figure 6-41. Arch dam.

exerted by the deep water behind the dam to cause failure of the entire structure.

★*d. Illustrative Example.* The following example illustrates the recommended procedure for selecting yields required to destroy concrete arch dams for various emplacement configurations.

Given: An arch dam, with dimensions as shown in figure 6-42, is to be destroyed.

Find: The yields required for the following emplacement positions as indicated in figure 6-42: ADM emplaced in inspection gallery; ADM emplaced on upstream face; and ADM emplaced on downstream face.

Solution: Position 1—Emplacement in Inspection Gallery. The distance to the upstream face is 27 feet and to the downstream face of the dam is 54 feet. Referring to figure 6-39 (curve b), the required yield is less than 0.01 kt; and for downstream distance, the required yield is 0.02 kt.

Answer: Yield required to breach the distance from the inspection gallery to upstream face of the dam is the critical yield (larger) and must be equal to or greater than 0.02 kt.

Position 2—Emplacement on Upstream Face of Dam. The ADM is emplaced on the upstream face 100 feet below the reservoir water level. With the ADM in this position, the dis-

tance to the downstream face is 44 feet. Referring to figure 6-39 (curve a) the required yield is .011 kt.

Answer: ADM yield to be used must, therefore, be equal to or greater than .011 kt.

Position 3—Emplacement on Downstream Face of Dam. The ADM is placed on downstream face of dam at the base of the dam as shown. With the ADM in this position, the distance to the upstream face is 88 feet. Referring to figure 6-39 (curve c) the required yield is 7.5 kt.

Answer: ADM yield to be used must, therefore, be equal to or greater than 7.5 kt.

6-26. Buttress Dams

a. Hollow buttressed dams (fig. 6-43) usually consist of a series of parallel, equidistant, concrete buttresses covered by a watertight, sloping upstream face. The downstream face of hollow buttressed dams and those on foundations susceptible to erosion are closed in to provide spillway facilities. All the structural elements of the buttress dam are constructed of reinforced concrete and generally are thinner than the structural components of either arch or gravity dams. By destroying a buttress, at least two spans of the dam will collapse. The two emplacement positions which will be discussed are—placement below the water level on the upstream face of the dam, and placement in contact with the buttress itself. If the buttress dam has a closed-in downstream spillway, the ADM may also be placed at a buttress location in the inspection shaft which runs through the buttress parallel to the main axis of the dam (fig. 6-44).

b. Yield selection for the destruction of buttress dams depends primarily on the extent of damage desired since the majority of the structural components are comparatively thin and therefore easily breached. If the intent is solely to release the impounded water, the upstream slab supported by the buttresses is easily breached. The required ADM yield (positions 1 and 2) may be determined from figure 6-39 for emplacement on the upstream face (curve a) or for emplacement on the downstream face of the slab (curve c). The same mechanisms considered in analyzing

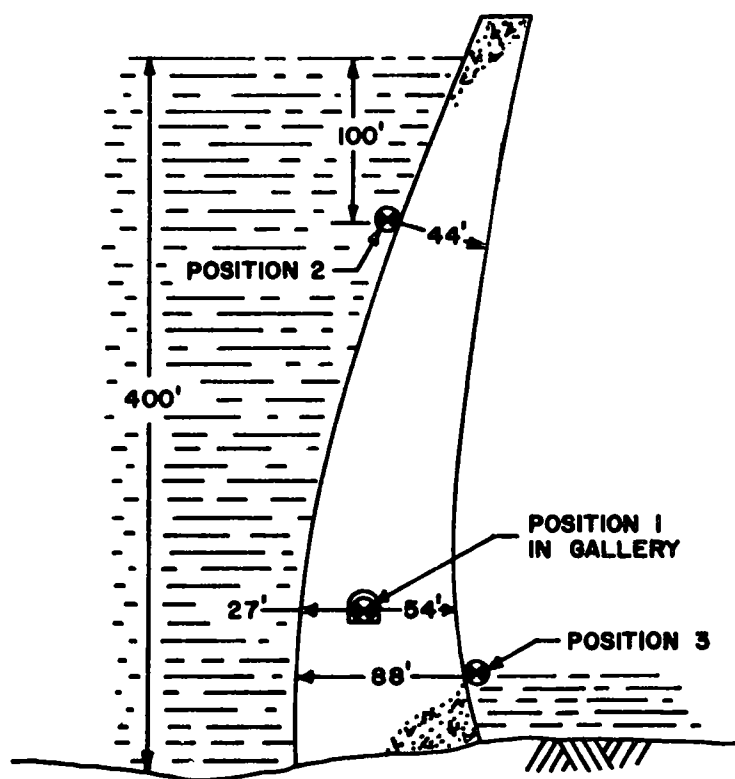


Figure 6-42. Concrete arch dam emplacement positions for illustrative example.



gravity and arch dams are applicable in this case. Emplacement on the downstream face of the slab adjacent to the buttress produces a certain amount of bonus damage to the buttress. Since the buttress itself functions much

like a bridge pier, yield determination for the destruction of the buttress (position 3) follows the same procedure described for bridge piers where the width of the base (B) is equated to the pier width.

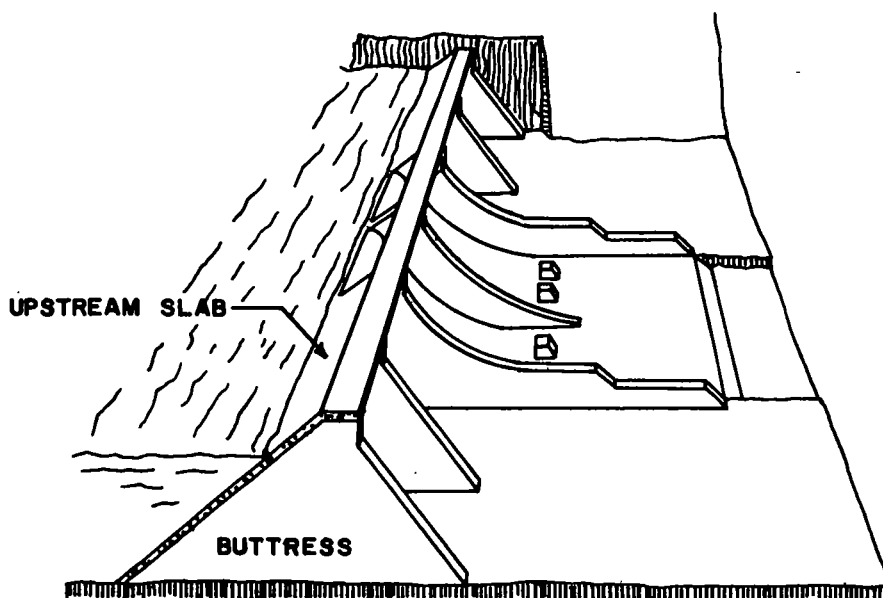


Figure 6-43. Buttress dam.

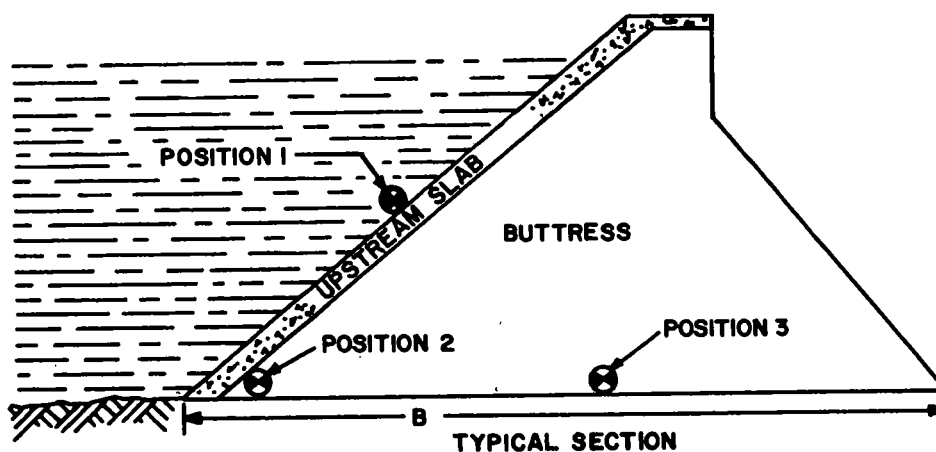


Figure 6-44. Buttress dam showing ADM emplacement positions.

6-27. Earth Dams

a. An *earth dam* is similar to an earthfill except that it contains an impervious core such as clay or an impervious blanket on the upstream face. A typical earth dam is shown in figure 6-45. The width of the crest of most earth dams is less than 40 feet (12 meters), and the upstream and downstream slopes are seldom steeper than a vertical to horizontal

ratio of 1 to 3 or 33 percent.

b. Earth dams may be effectively destroyed by detonating an ADM beneath or on the crest of the dam. Detonation of the ADM below the crest of the dam requires a smaller yield due to enhancement of cratering effects, and the amount of radioactivity released to the atmosphere is correspondingly reduced for comparatively deep depths of burial.

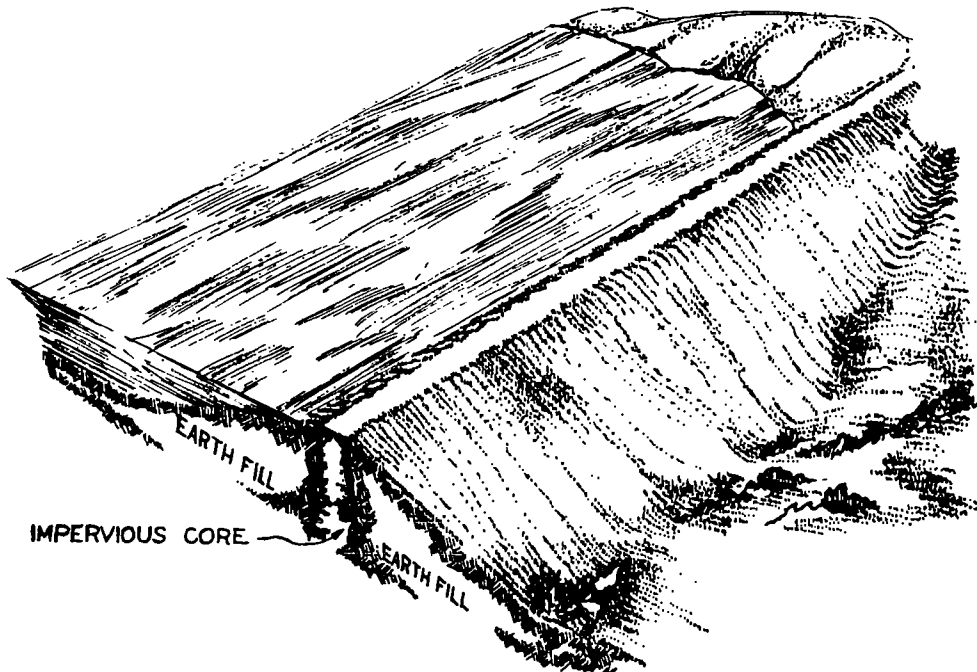


Figure 6-45. Earthfill dam.

c. The yield required to destroy an earth dam is determined graphically. The criteria used is based on achieving a true crater with dimensions of sufficient magnitude to allow for an initial breach of at least 10 feet (3 meters) below the water level. This breach will provide a sufficient outflow of water so that erosive forces will cause complete destruction. Based on the emplacement position on or beneath the crest of the dam (fig. 6-46), the true crater radius is determined from the cratering tables (true crater radius equals ap-

parent crater radius) and the true depth (H_T) is calculated using the equation $H_T = DOB + 45 W^{1/2}$ feet ($H_T = DOB + 14 W^{1/2}$ meters). Disregarding the emplacement position, the R_A and H_T are plotted to scale on the cross section of the dam from the center of the crest. A line is then drawn connecting R_A and H_T ; at the intersection of this line with the upstream face of the dam, the distance to the water level is measured. This distance must be at least 10 feet (3 meters); otherwise, a second analysis based on an in-

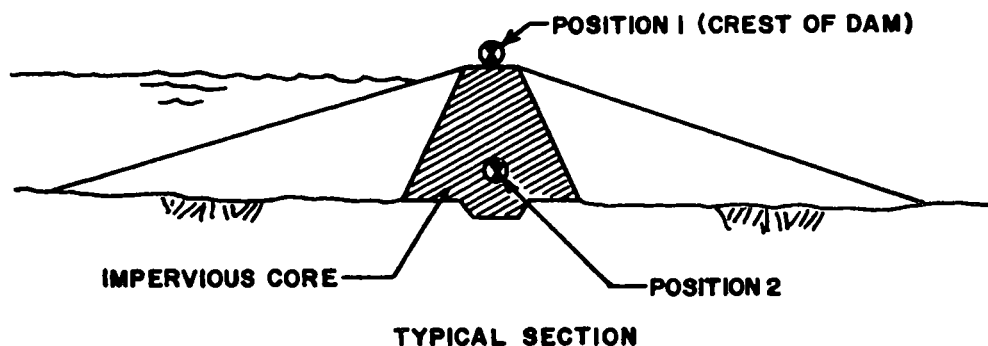


Figure 6-46. Typical earth dam and ADM emplacement positions.

creased yield or deeper depth of burial must be tried. This method is valid only in those cases where the ADM is emplaced on or beneath the center of the crest. Should emplacement be made on the upstream face with the view of inducing structural failure, the analysis is reduced to a visual inspection of postshot conditions to ascertain if the damage is adequate.

★*d. Illustrative Example.* The following example illustrates the recommended procedure for selecting yields required to destroy earth dams.

Given: The dam shown in figure 6-47 is scheduled for demolition. Two ADM have been allocated, a BRAVO/1 kt and DELTA/5 kt. Fallout is not be considered a limiting factor; also, emplacement capabilities permit ADM burial to a depth of 30 feet.

Find: The yield and emplacement position required to destroy the dam.

Solution:

(1) The lower yield (1 kt) and the least difficult emplacement position (on the crest) is considered first.

(2) The D_A for a surface burst from appendix II (table II-3) for a 1-kt ADM is 40 meters (131 feet); the R_A , therefore, equals 65 feet. The true depth is calculated as follows: $H_T = DOB + 45 W^{0.3} = 0 + 45 (1) = 45$ feet.

(3) Plotting these values to scale and then connecting the R_A and H_T plots, it is found that the initial breach occurs approximately at the water level and is inadequate.

(4) Rather than go to the next higher

yield in view of the known burial capability, another trial at a $DOB = 15$ feet is repeated. The R_A at a $DOB = 15$ feet is found to be 108 feet (fig. 6-2) and the $H_T = 15 + 45 = 60$ feet. The increase in values of R_A and H_T due to burial is shown with a broken line. The initial breach is now 15 feet which meets the criteria for destruction of earth dams.

Answer: Therefore, the ADM recommended is the BRAVO/1 kt emplaced 15 feet below the center of the crest.

6-28. Emplacement Upstream From Dam

The breaches achieved with ADM placed at the previously discussed locations are produced primarily by the cratering effect of the blast. A nuclear detonation upstream, so that the dam is outside the cratering radius, can also cause failure by the action of the hydrostatic pressure and shock waves generated by the detonation. This effect may result in the overturning, sliding, or cracking of the structure. See TM 23-200 regarding the effect of blast and shock on dams.

6-29. Gate Blowout

a. An important function in the operation of any dam is the regulation of flow over or through the structure. In most cases, this is accomplished by flood (spillway) gates (fig. 6-48) which regulate flow over the top of the structure and sluice gates which control the flow in tunnels through the dam. Some dams have only one type of outlet while others have both.

b. The strength of sluice gates has been found to be such that any nuclear detonation

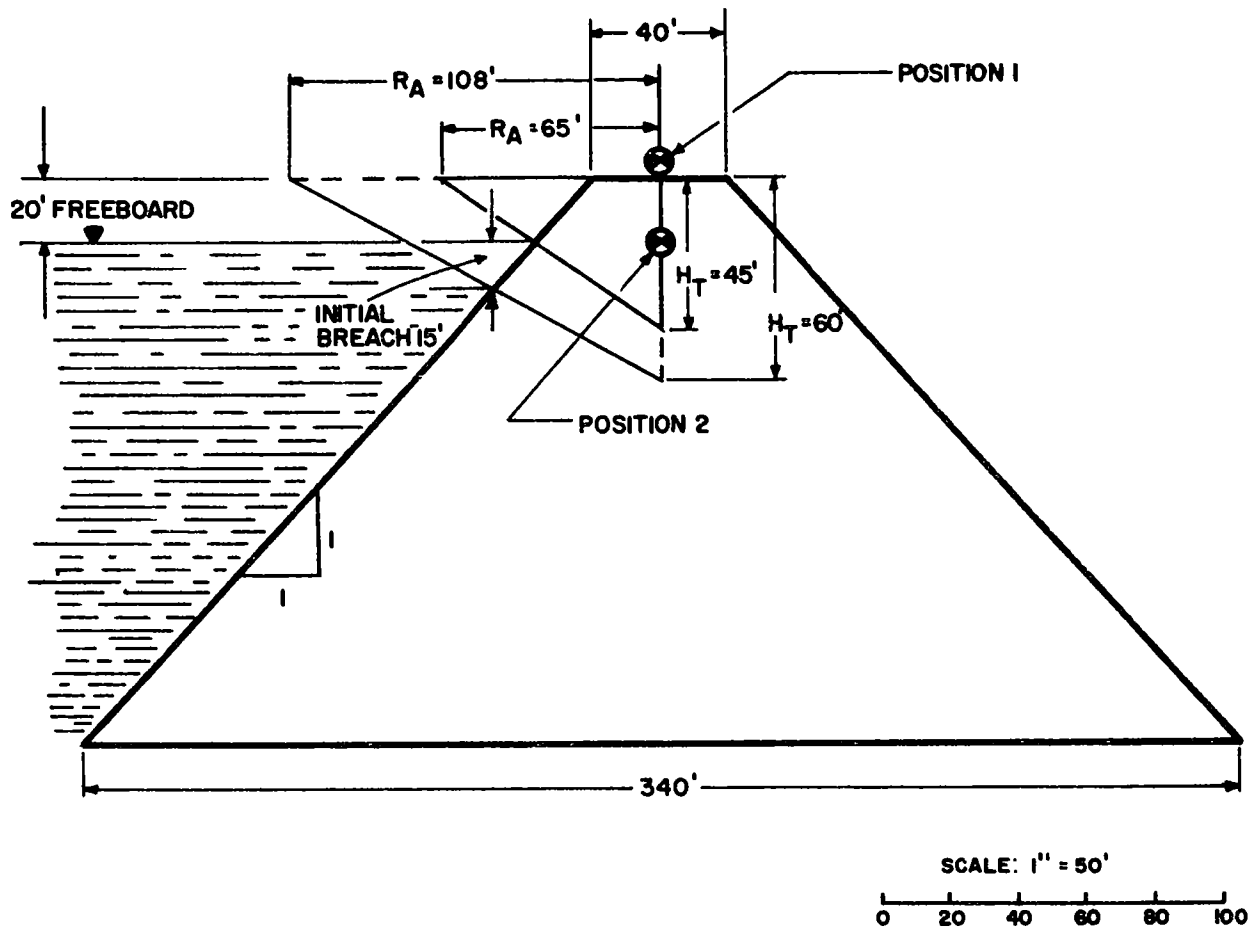
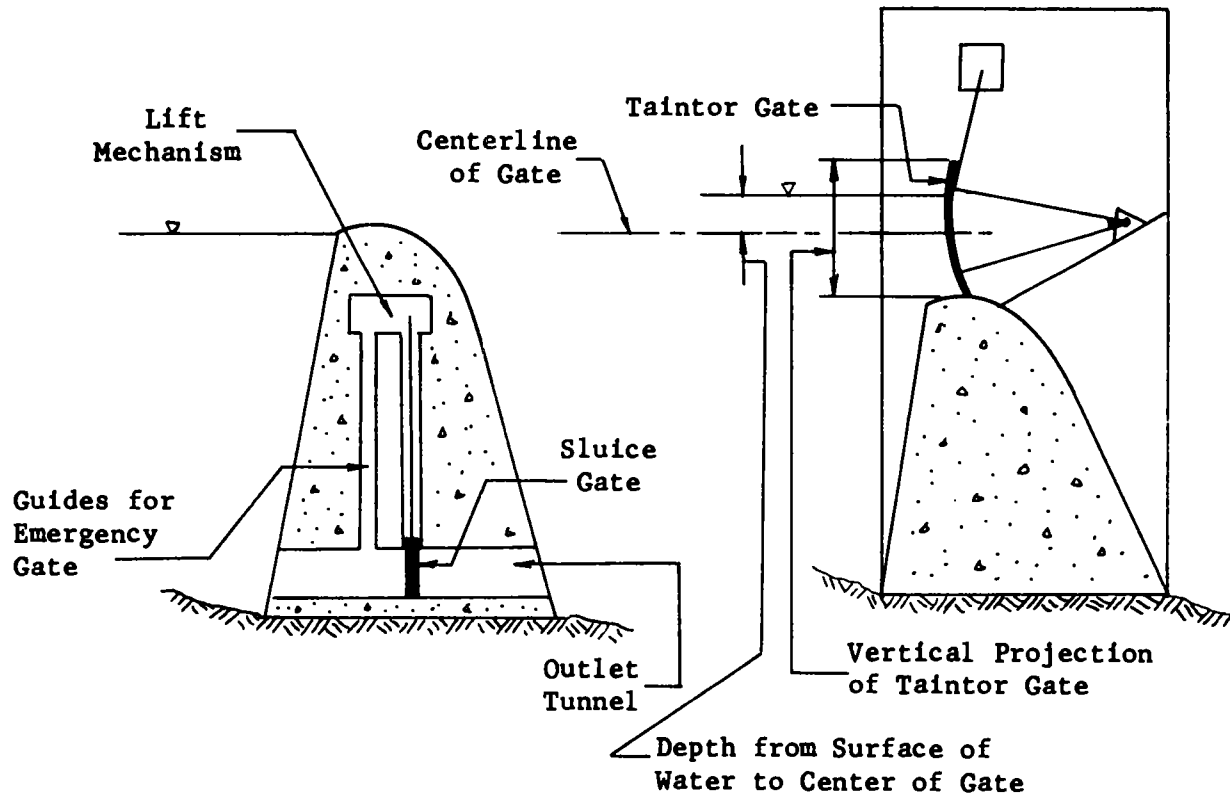


Figure 6-47. Graphical solution to earth dam illustrative problem.

large enough and close enough to blow out the gates also causes cracking and probable failure of the dam itself.

★ c. Depending upon the design of the dam, the spillway gates may extend along the entire dam or only along a small portion of its length. Spillway gates are usually the most vulnerable part of the dam. Although accessible taintor gates (a common spillway gate) are usually

more vulnerable to conventional demolition charges applied to the lower radial strut, they may be blown out by the hydrostatic shock wave generated by nuclear detonation underwater upstream from the reservoir. This may be achieved without severe damage to the dam itself. The distance, of course, depends upon the size of the munition and the installation and strength of the gates. Other types of spillway gates may be expected to react similarly.



SLUICE GATE

Figure 6-48. Cross sections of sluice and spillway gates.

6-30. Downstream Flood

a. In any plan for destruction of a dam, one of the important considerations is the magnitude of the resulting flood. Many factors combine to determine the size and destructiveness of such a flood. It is beyond the scope of this manual to provide a detailed system of analysis for flood prediction. If the extent of such a flood must be estimated accurately, the actual conditions at and below the dam should be analyzed by a military hydrologist.

b. A rough estimate of the magnitude of the flood may be obtained by assessing the following factors:

(1) *Quantity (acre-feet) of water available (the amount of water available at any given time in a reservoir).* If the primary purpose of the dam is for electric power generation, the water level is kept as high as possible to extract the maximum energy from the falling water. On the other hand, if the dam is for flood control, the reservoir is normally kept as empty as possible to provide the maximum catch basin. Reservoir levels behind dams used for water regulation vary widely depending on the interplay of water input and demand.

(2) *Gap (or weir) created.* The size of the breach blown in the dam determines how quickly the water is released. As indicated earlier, arch dams will probably undergo complete

and sudden failure, thus approximating the ideal case which is sudden and complete disappearance of the dam. Gravity dams do not fail in this fashion; rather, a breach causes water to run out gradually. As indicated earlier, erosion plays a large part in breaching earthfill dams—even a small initial breach may be rapidly expanded by the water itself. If a sudden release of the maximum amount of water is desired from a gravity or earthfill dam, a larger yield or multiple burst is required.

(3) *Topography.* The shape and slope of the downstream river basin strongly affect the speed and depth of the released water. A large open plain dissipates the energy of the water and diminishes the height of the flood crest. Conversely, a narrow, steep gorge coupled with decreasing flood elevation accelerates the water and keeps the depth peaked for maximum destruction. Upstream topography is also important since it determines how quickly the stored water can be delivered to the dam site.

(4) *Initial head.* The initial acceleration of the water is determined by the height through which it initially falls as the dam is breached. A high dam provides a much greater "wall of water" than a low dam. Moreover, the velocity which the released water attains significantly influences the damage created downstream.

Section V. CANALS

6-31. General

a. Canals vary considerably in complexity. At one extreme is the single level canal, dug through an area only slightly above sea level and requiring no locks or lifts; at the other extreme is the canal which must raise ships over a terrain barrier. These multi-level canals employ systems of locks and gates, storage reservoirs, and pumps.

b. As a rule, the more complicated the system, the easier it is to put it out of operation and the more difficult to repair. Because of the differences in size and construction of canals, however, no specific directions for demolition applicable to all cases are possible. Each target

must be analyzed individually to determine its vulnerable points.

c. Inland waterways and their auxiliary facilities are subject primarily to the effects of blast, cratering, hydrostatic pressure, and ground shock. In the selection and placement of an ADM for the disruption of an inland navigation system, the governing effect is determined; and an ADM of approximate yield is selected.

d. Nuclear detonations are very effective when properly employed; however, there are occasions when conventional explosives can be used more efficiently or when nuclear detona-

tions would cause an undesirable level of damage. Thus, a detailed analysis of the canal system is necessary to insure that available munitions are employed effectively and that undesired damage is avoided.

6-32. Single Level Canals

The single level canal is the most difficult to put out of operation. Its relative invulnerability lies in its simplicity. It is a ditch connecting two natural bodies of water. Its water supply is inexhaustible, and no mechanism is required to regulate the waterflow. The only practicable way to put a single level canal out of service is to block it. This may be accomplished with varying degrees of success by earthslides or ships.

a. Blocking With Earthslide. Blocking a canal with an earthslide is possible only in rare circumstances. The optimum conditions demand a soil with low cohesive strength and a relatively steep bank, high enough to leave a sufficient volume of earth after the blast to form a canal-blocking slide. Because cuts for canals are usually designed expressly with slide prevention in mind, the occurrence of these conditions is infrequent. Nevertheless, cratering data as discussed in paragraphs 6-3 through 6-14 regarding the creation of landslides also are applicable to canals.

b. Use of Block Ships. The sinking of ships in a canal is an effective, expedient means of blocking. Conventional explosives or other means of scuttling normally are used for this purpose.

6-33. Variable Level Canals

a. The variable level canal, as a rule, cannot be considered as a single feature distinct from its surroundings. It is more likely a part of a larger system which exploits one or more watersheds. In addition to providing navigable wa-

terways, such a system may involve power generation, water conservation, flood control, irrigation, and fish migration. Disruption of the facilities which permit navigation on such a system is likely to affect all the other functions as well.

b. If it is desirable to damage only the navigational facilities and to leave the remainder of a system intact, extreme care is necessary when employing ADM against specific targets.

(1) *Dams.* In planning denial of a navigational system, the basic mission must be borne in mind. If it is desired to achieve the greatest possible damage, destruction of the dam which impounds the water for the system may be more profitable than an attack on the lock facilities that allow vessels to bypass the dam. Destruction of the dam not only prevents navigation—even with all its other facilities intact—but puts an end to power generation, irrigation, and flood control. Additional damage may be done by the release of the impounded water. If the dam is to be the target, the data and methods presented in paragraphs 6-23 through 6-30 are used.

(2) *Locks.* A lock is the most common system for raising or lowering vessels. To pass a vessel headed downstream, the lower gate is closed; and by means of a system of valves and ducts, the lock chamber is filled with water. The vessel enters the chamber and the upper gate is closed behind it. Through additional valves and ducts, the water is drained out of the chamber to the lower level of the canal. The lower gate is then opened and the vessel can proceed. The lower gate must be the full height of the chamber; the upper gate need extend only from the highest water level to a safe margin below the deepest

draft vessel handled. The essential elements are the gates, lock chamber, operating machinery, and valves.

(a) *Machinery.* When limiting effects preclude the use of ADM large enough to damage harder features, valves and machinery may be attacked with conventional explosives. However, when the gates and chambers are targeted, no specific attention to valves and machinery is required for a nuclear explosion which damages the gates and chamber will most likely damage this equipment as well.

(b) *Lock chambers.* Lock chambers are generally constructed of concrete or masonry. In rendering a chamber unusable, cratering is the governing effect. The best results are gained by ADM placement on the face of the end wall near the gate. Ground shock may also result in damage and is considered a bonus.

(c) *Gates.*

1. Lock gates may be hinged at the side or bottom; they may slide vertically below the bottom of the channel or be raised above the channel; they may slide horizontally into the side walls or move on rails against the side walls. Gates are vulnerable to hydrostatic shock and dynamic pres-

ures. Although they are designed to withstand static pressure, a large detonation will exceed the safety factor. The downstream gate is particularly vulnerable because its large surface presents a greater area on which the pressure can act. When the lock is full, it is already loaded on the chamber side with the static pressure for which it was designed whereas the other side is virtually unsupported.

2. For maximum destruction, the ADM is placed underwater in the upstream end of the chamber near the upper gate or against the upstream chamber wall thereby destroying the gates and cratering the chamber. For best results the lock is full with all gates and valves closed at the time of detonation. If placed as recommended, any yield can be expected to destroy the upper gate; the yield required to remove the lower gate may be determined from figure 6-49. Time or limited access may preclude optimum placement of the ADM. If so, considerable damage can be done to locks and gates by detonating an ADM in the near vicinity of the facility.

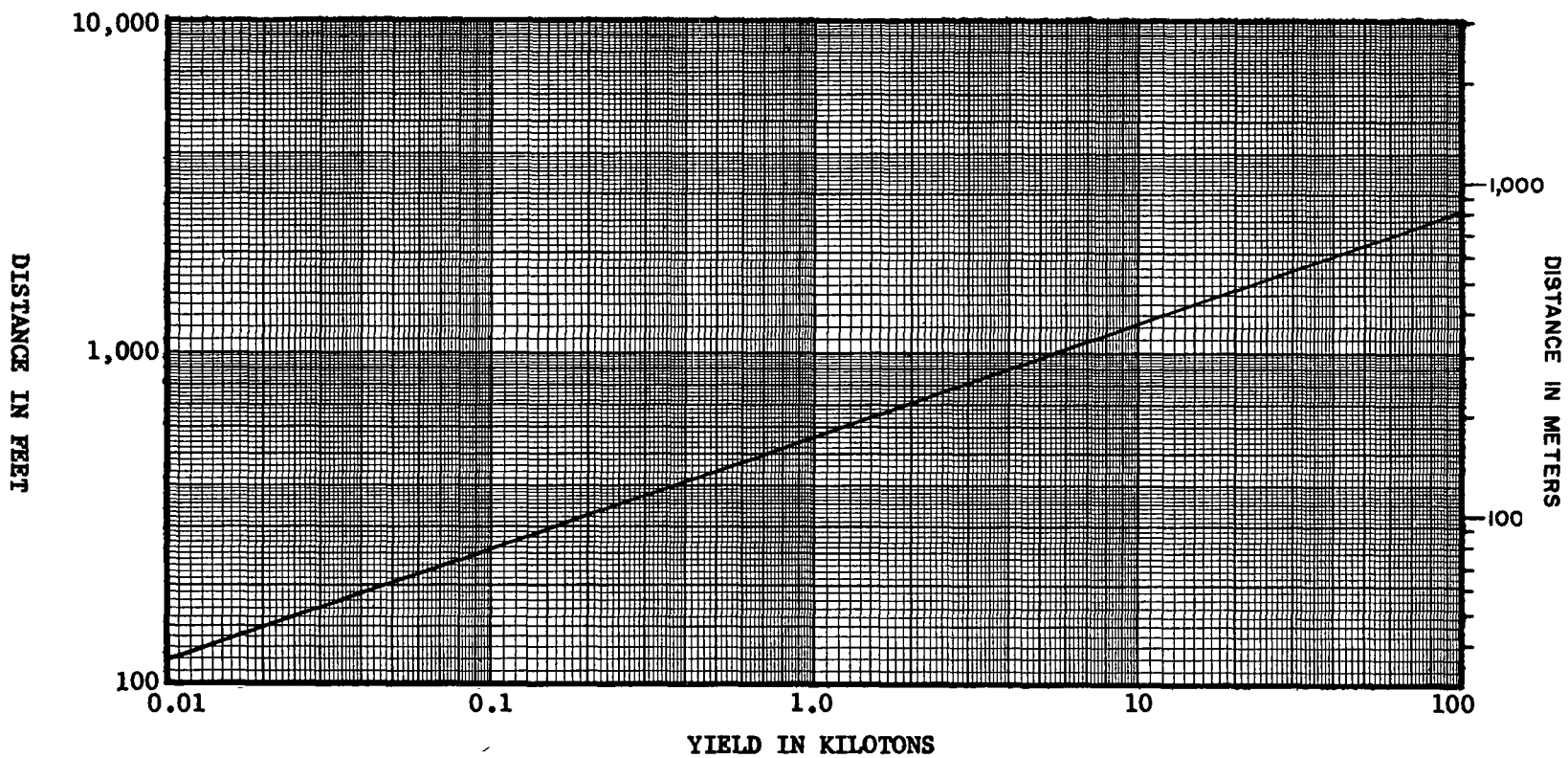


Figure 6-49. Distance versus yield for removal of downstream gates.

3. A lock chamber may be equipped with more than one set of gates to adjust the length of the lock to the length of the vessel to be passed. Another feature frequently found is a gate upstream of the main gate to permit the entire lock system to be drained for inspection and maintenance. *For maximum effect, all gates and valves are closed before detonation.*

(d) *Multiple locks.*

1. Locks frequently are built side by

side to conserve water by passing upstream and downstream traffic at the same time. To save water, adjacent chambers of double locks are usually connected so that the water drained from one can be run into the other until the levels are equal (fig. 6-50). The ducts connecting the chambers offer a good location for placing a munition underground between two chambers, thus destroying both at once.

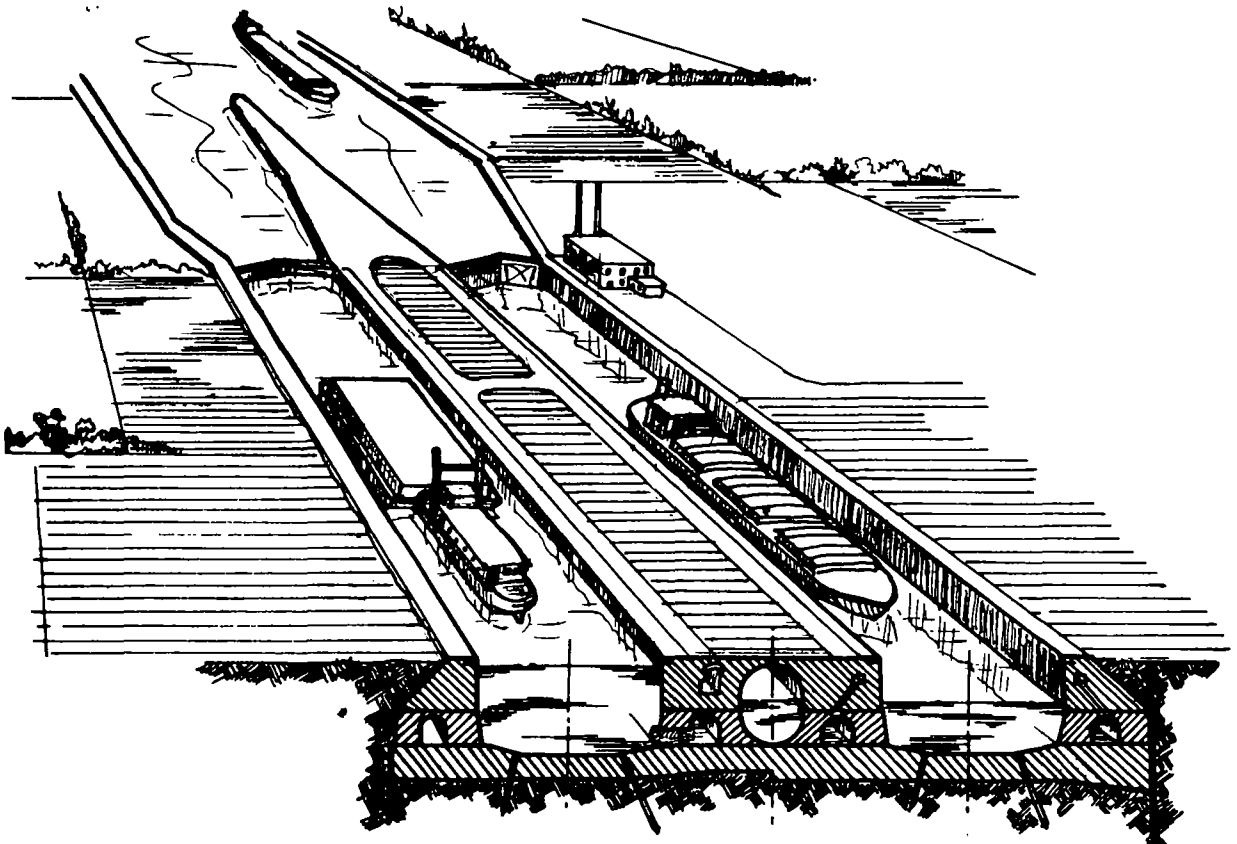


Figure 6-50. Double lock.

2. Parallel locks are not always adjacent; they are sometimes separated by water conservation basins which may require a separate demolition in each lock chamber.
- (3) *Lifts.* Extreme changes in elevation may be accomplished by means of a lift, a form of elevator which raises or lowers a large trough of water in which the ship is floating. The ship moves into and out of the trough in much the same manner as it enters and leaves a lock; the lifting mechanism may be hydraulic or mechanical or a combination of both. The weight of the trough may be counterbalanced by using identical troughs in a double lift with both supported on hydraulic columns running in interconnected chambers, by a system of floats, or by counterweights.
 - (a) *Double hydraulic counterpoise.* The double hydraulic counterpoise lift can be destroyed by an ADM placed so that the resultant crater breaches both cylinders.
 - (b) *Float counterpoise lift.* A lift with float-type counterpoise is shown in figure 6-51. The cratering action of an ADM placed on the surface at the foot of one of the towers will breach two of the float chambers and destroy the tower, thereby severely damaging the trough. The most critical components of the whole lift system are its elevating screws; placement against a screw destroys at least one of them. The upstream tower is the favored location so as to make bonus damage more likely to the upper canal level and loss of water to the system resulting in flooding.

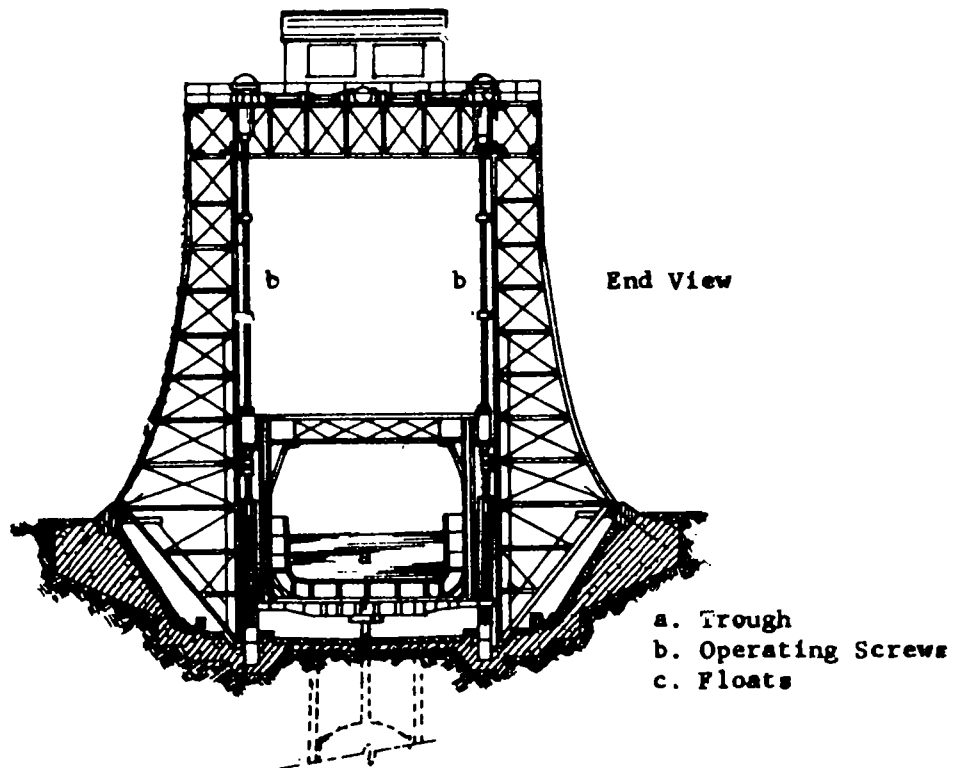
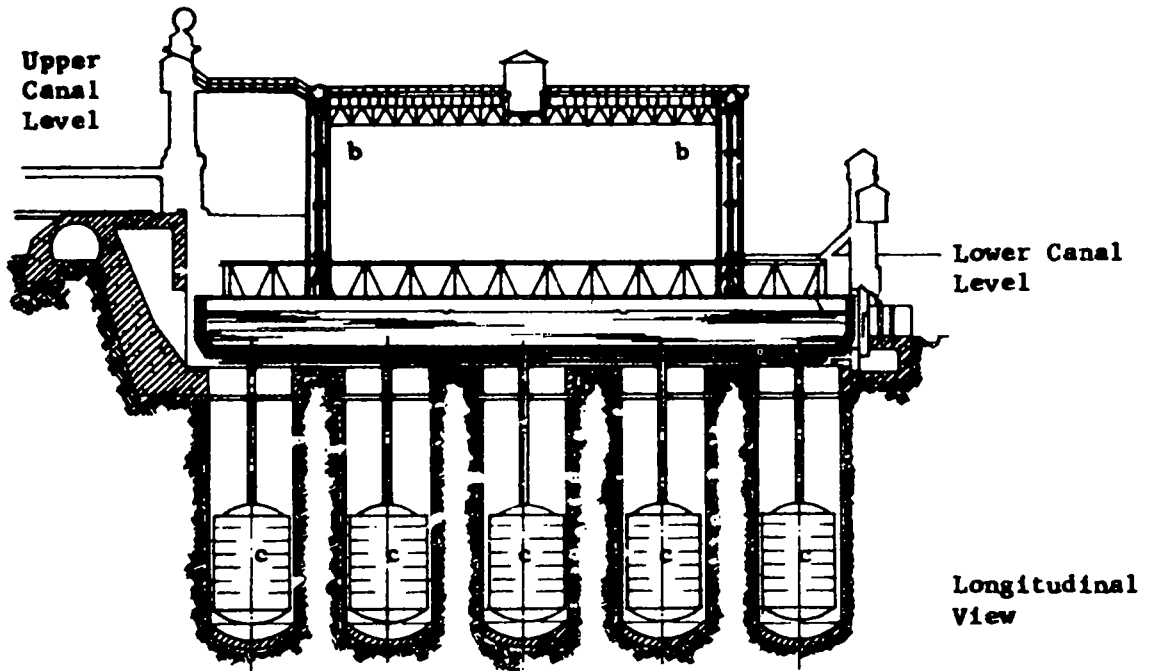


Figure 6-51. Example of vertical lift.

(4) *Pumps.*

(a) Water generally flows through a lock system by gravity, and pumps are not essential to the operation. In areas where water is scarce, water may be returned to a storage reservoir or to another lock by pumping rather than released to flow downstream. Destruction of the pumps in such a system decreases its capability by preventing the conservation of the water but does not completely prevent the use of the locks.

(b) When there is no natural water supply and the entire canal system is artificial, the pumps are vital.

(c) An ADM of any size will temporarily disrupt the operation of a pumping station by destroying the building, controls, powerlines, and other facilities; however, the items most difficult to replace are the pumps themselves. In a large pumping station, the pumps

may be distributed over an area so large that one munition of reasonable yield will not cause the required damage to them all. In such a case, conventional demolition charges applied to each pump are more efficient and practical.

(5) *Channels.* When a canal is above the surface of the adjoining ground, it may be drained by blowing out one of the embankments in the same manner as breaching an earthfill dam (para 6-27).

(6) *Aqueducts.* Canals are particularly vulnerable where they cross roads, valleys, or other waterways on aqueducts. An aqueduct is nothing more than a bridge which carries water, thus destruction of an aqueduct is performed in the same manner as that of any bridge of similar construction (para 6-15 through 6-22).

Section VI. TUNNELS

6-34. General

This section is provided for the analyst interested in the destruction of or damage to underground or underwater tunnels using ADM. Curves, illustrations, and technical data have been provided so that reasonable estimates of yields and damage may be made.

6-35. Description of Damage

Tunnel damage is classified into four decreasing degrees of damage called zones 1, 2, 3, and 4. Figure 6-52 shows a typical damage profile from a subsurface burst (not in the tunnel) with damage zones and damage radii labeled. Tunnel damage is described as follows:

a. Zone 1: Complete Damage. Rock is completely crushed to a radius defined by the compressive strength of the rock. Beyond the area of complete crushing, rock is propelled from all sides of the tunnel causing complete closure. In this zone, a damage profile does not

exist. The outer limit of zone 1 marks the end of the damage profile.

b. Zone 2: Rock Breakage (fig. 6-53). Rock breakage is continuous and increases in thickness nearer to the detonation. Sizeable amounts of rock are broken, and the pieces are large and block-like. The point of closure occurs within this zone where broken rock completely fills the tunnel. Under certain conditions, the extremely high temperatures and pressures may squeeze the surrounding rock into a solid mass.

c. Zone 3: Continuous Slabbing (fig. 6-54). Rock breakage is continuous and relatively uniform in thickness; it is principally on the side toward the detonation. Zone 3 ends where rock breakage and the damage profile becomes continuous.

d. Zone 4: Discontinuous Damage (fig. 6-55). Rock breakage is irregular and inter-

mittent; breakage may include dislodgment of material previously loosened by tunnel traffic. The damage profile is discontinuous

in this zone. The inner limit of zone 4 is that point at which significant rock breakage begins.

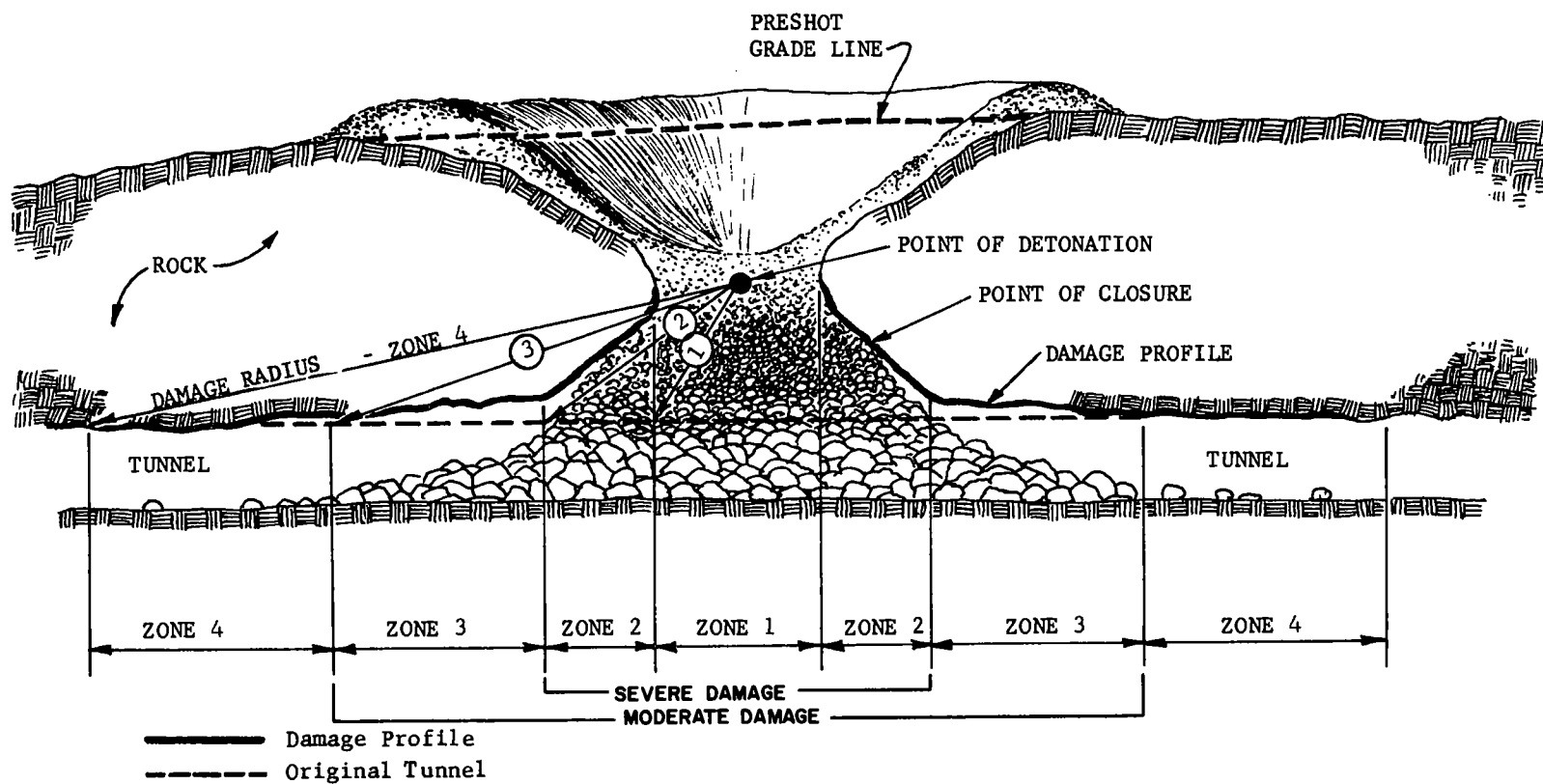


Figure 6-52. Tunnel profile showing zones of damage.

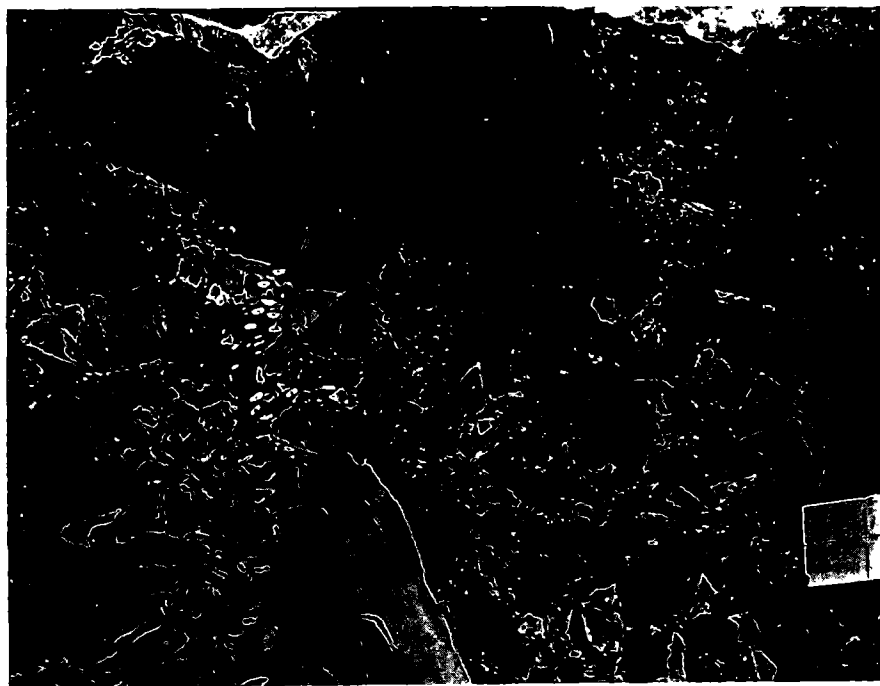


Figure 6-53. Access tunnel—zone 2 damage.

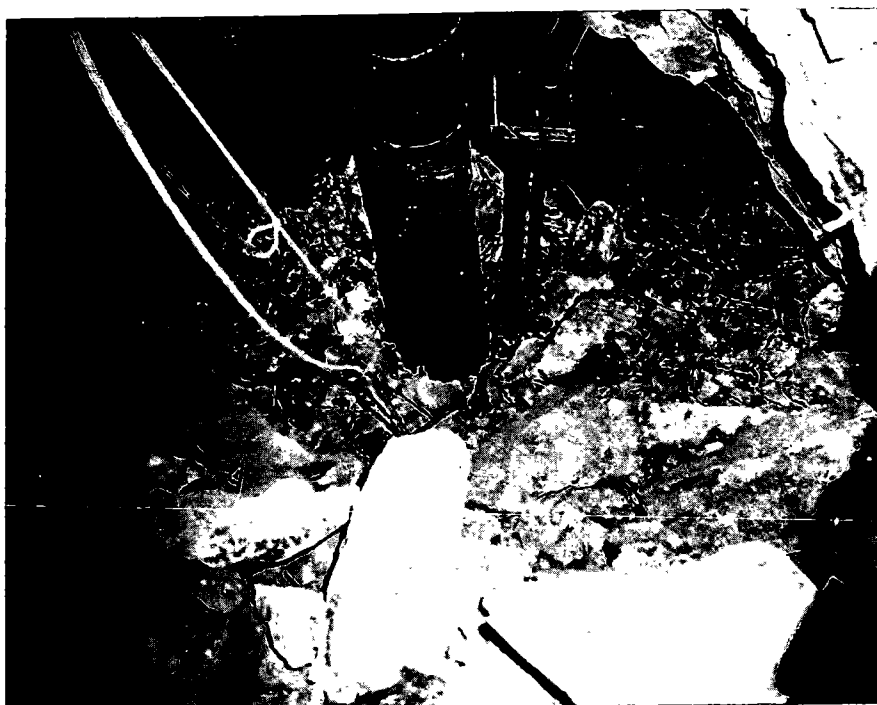


Figure 6-54. Access tunnel—zone 3 damage.

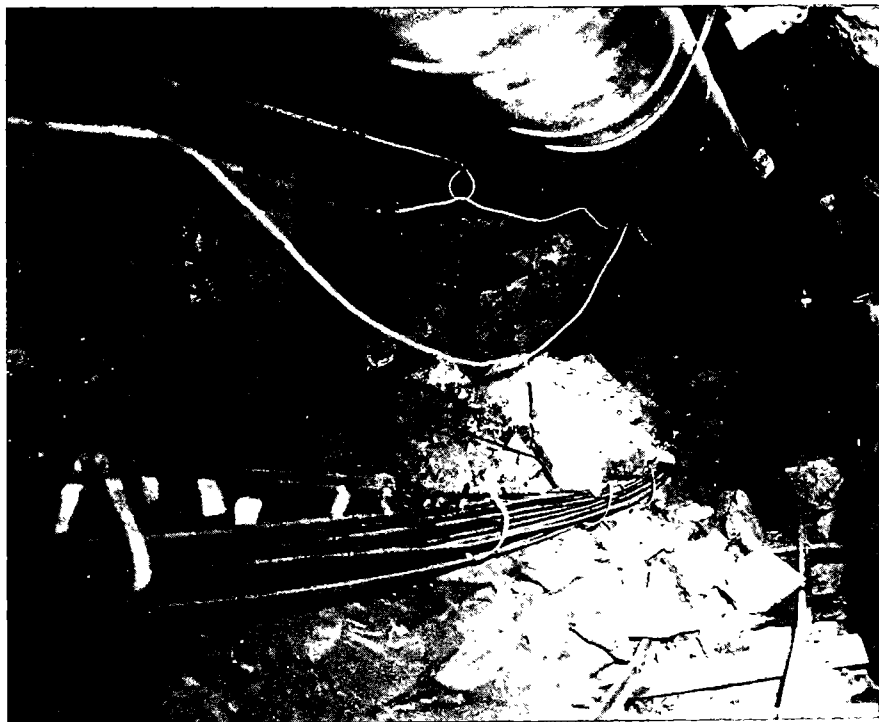


Figure 6-55. Access tunnel—zone 4 damage.

6-36. Military Significance of Damage

a. Zone 1. As previously described, the material within zone 1 is completely crushed from the burst point to the tunnel and requires standard tunneling procedures for reentry. In addition, a radiological hazard may exist for a period of days and in any event, considerable caution would have to be exercised upon reentry.

b. Zone 2. Within zone 2, the tunnel is considered destroyed and generally requires use of standard tunneling procedures for repair. In this zone the volume of broken material varies from 80 to over 100 percent of the volume of the original tunnel. There may be residual radiation in the tunnel in zone 2 if there are fissures or cracks leading from the

burst point through which gases can enter. Closure occurs within zone 2 at the point where dislodged material completely fills the tunnel opening. Under certain conditions, the tunnel may be completely closed with solid rock.

c. Zone 3. Damage in zone 3 is described as moderate. The tunnel will be partially filled and will require removal of large amounts of broken material from the tunnel lining and the rock itself. Floor heave may be extensive and will probably require re-leveling prior to normal use by wheeled vehicles. The tunnel may be passable on foot in this zone without recovery work.

d. Zone 4. For military purposes, damage in zone 4 is considered insignificant. The small

amount of rock or lining material dislodged from the tunnel roof and walls can be easily removed. Floor displacement should not hinder vehicular traffic. However, it is likely that the floor displacement in a railroad tunnel will be sufficient to require realignment of rails.

6-37. Damage-Distance Relationships

a. The distances which are used to establish damage criteria are as follows (fig. 6-56):

- (1) *Burst to tunnel distance*. Shortest distance from explosive to tunnel face.
- (2) *Damage radius*. Radial distance from the ADM to tunnel face at the limit of the particular zone of damage.
- (3) *Horizontal damage distance*. Distance measured along the tunnel between the limits of the particular zone of damage.

b. The degree of damage achieved within a tunnel is strongly influenced by the location of the burst in relation to the tunnel. Figure 6-57 illustrates six typical emplacement locations as follows:

- (1) Surface burst
(directly over tunnel) ---Position 1
- (2) Surface burst
(not over tunnel) -----Position 2
- (3) Underground burst
(directly over tunnel) ---Position 3
- (4) Underground burst
(not over tunnel) -----Position 4
- (5) Burst offset from tunnel --Position 5
- (6) Burst on tunnel floor ----Position 6

c. As far as damage to the tunnel is concerned for a given yield and for a constant burst-to-tunnel distance, no difference exists between positions 1 and 2 nor between positions 3 and 4.

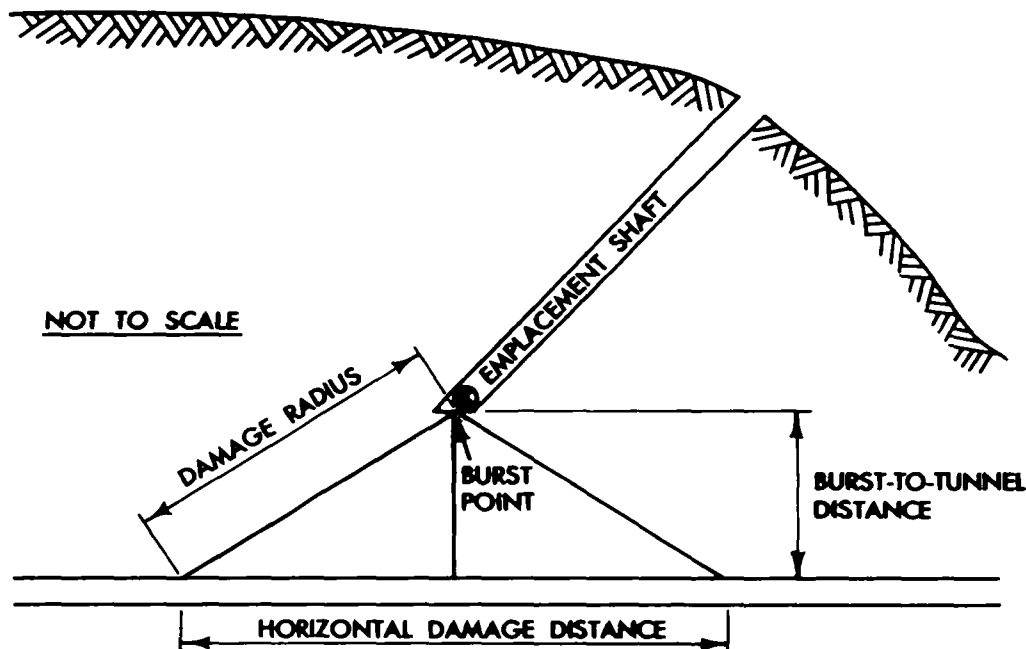
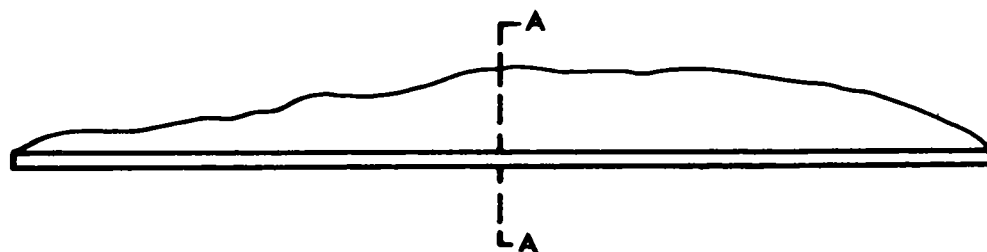
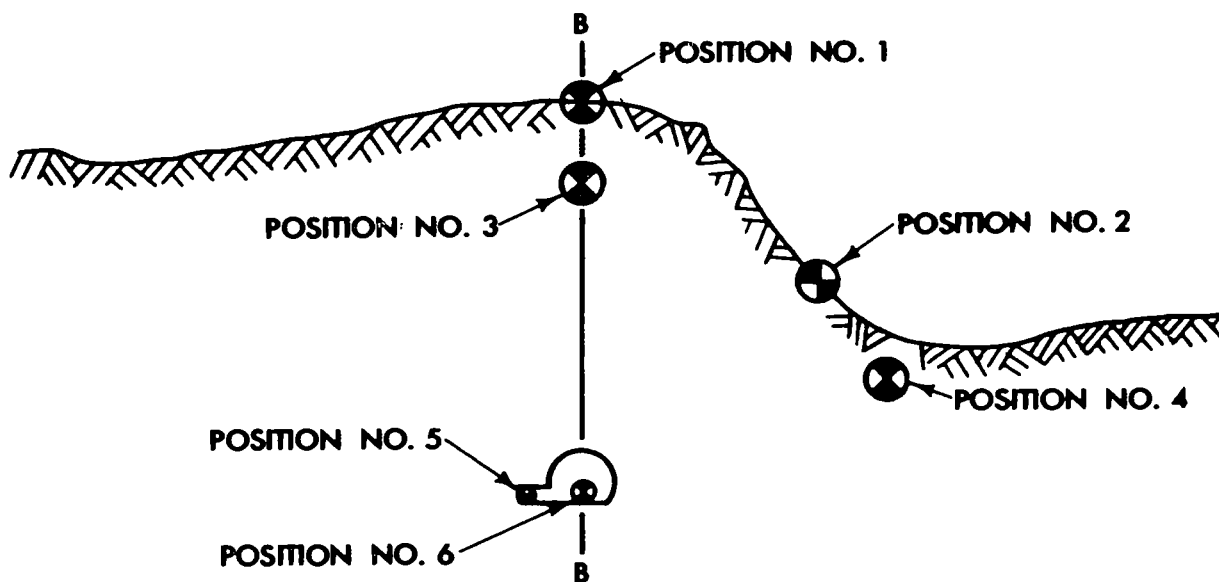


Figure 6-56. Damage-distance relationship.



a. LONGITUDINAL PROFILE ALONG B-B



b. SECTION A-A

Figure 6-57. Typical emplacement positions.

6-38. Types of Burst

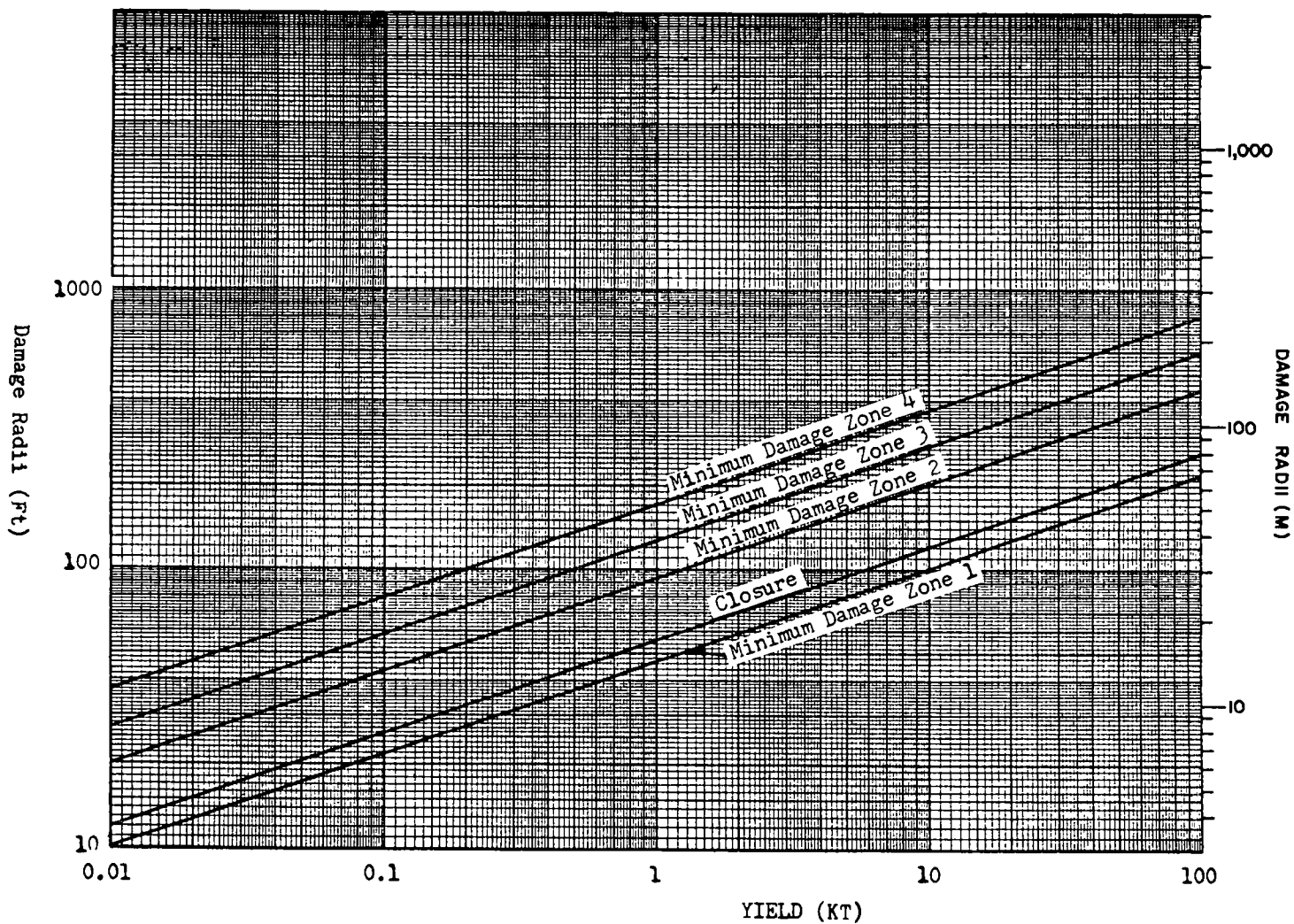
a. *Surface Burst.* Radii of the various zones of damage are given in figure 6-58 as a function of yield.

★b. *Underground Burst.* For purposes of tunnel destruction, an underground burst is de-

fined as one occurring at a point below the ground surface but not in the tunnel. Damage radii from an underground burst increases with depth of burial until a depth is reached at which all the mechanical energy released by the burst is translated into ground shock

(fully coupled). The tamping and coupling effect that results from a subsurface burst increases damage radii. For depths of burst between 0 and $160 W^{0.3}$ feet ($49 W^{0.3}$ meters), the surface burst damage radii (fig. 6-58) must be multiplied by the coupling factors obtained from figure 6-59 to arrive at damage radii for underground bursts. This multiplication has been incorporated into figure 6-60 which gives zone 1 damage radii as a function of yield for varying depths of burial. Radii for other damage zones can be obtained from figure 6-61 with the yield. Translation of damage radii to horizontal damage distance within the tunnel is accomplished through use of the nomograph presented in figure 6-62. To be

fully coupled, the emplacement must be far enough from the tunnel to prevent the explosion from venting into the tunnel before the cavity reaches its maximum size. This maximum cavity radius is presently estimated at $45 W^{1/3}$ feet ($14 W^{1/3}$ meters) in soil. To increase the probability of achieving full coupling, a safety factor of 50 percent is added. This results in a minimum burst to tunnel distance of $65 W^{1/3}$ feet ($20 W^{1/3}$ meters). Figure 6-63 shows the optimum condition of emplacement which is at least $160 W^{0.3}$ feet ($49 W^{0.3}$ meters) from the surface and $65 W^{1/3}$ feet ($20 W^{1/3}$ meters) from the tunnel. The closure line in figures 6-58 and 6-61 designates the point of closure (para 6-35b and fig. 6-52).



★Figure 6-58. Yield versus damage radii to unlined tunnels in rock for a surface burst.

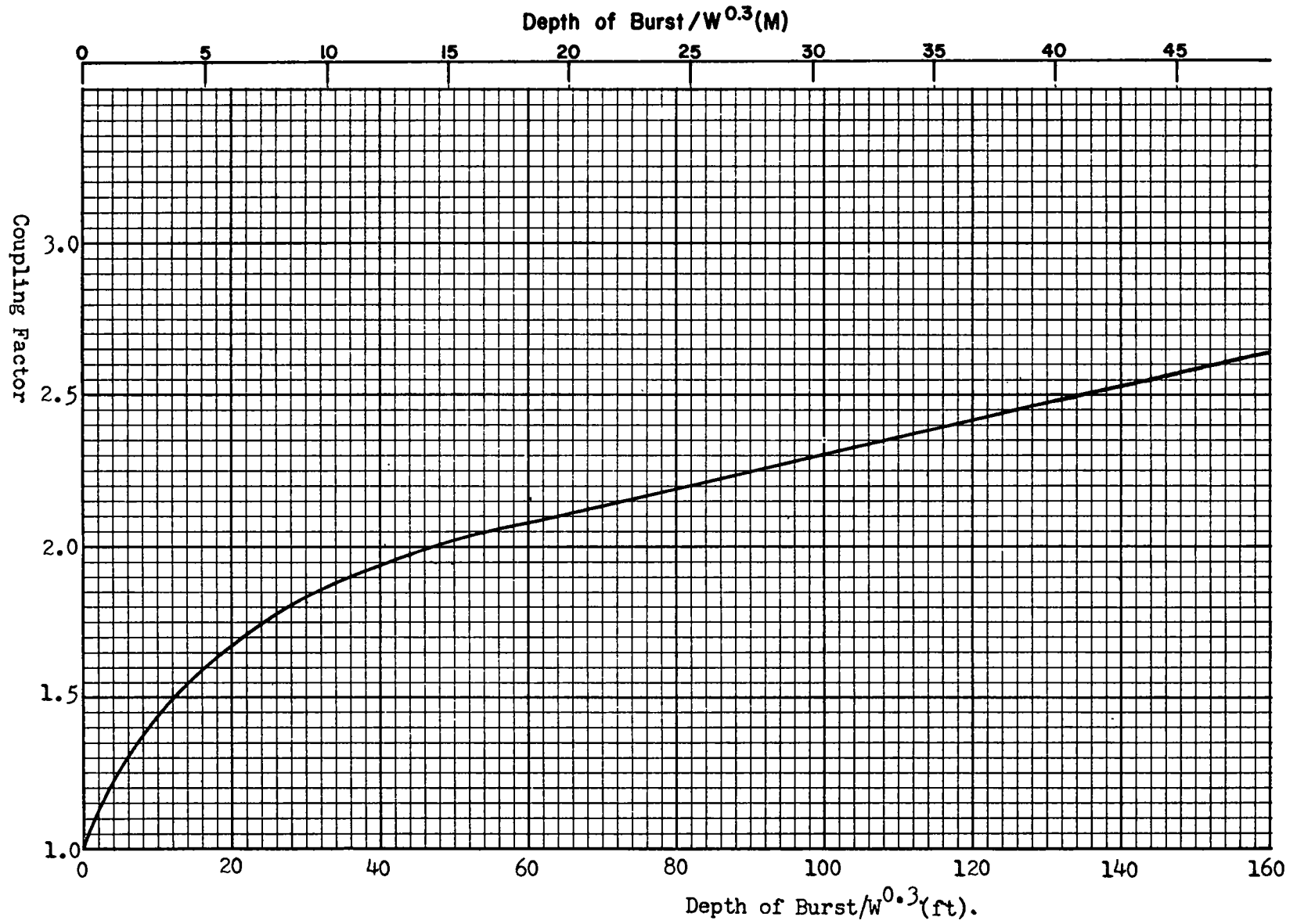
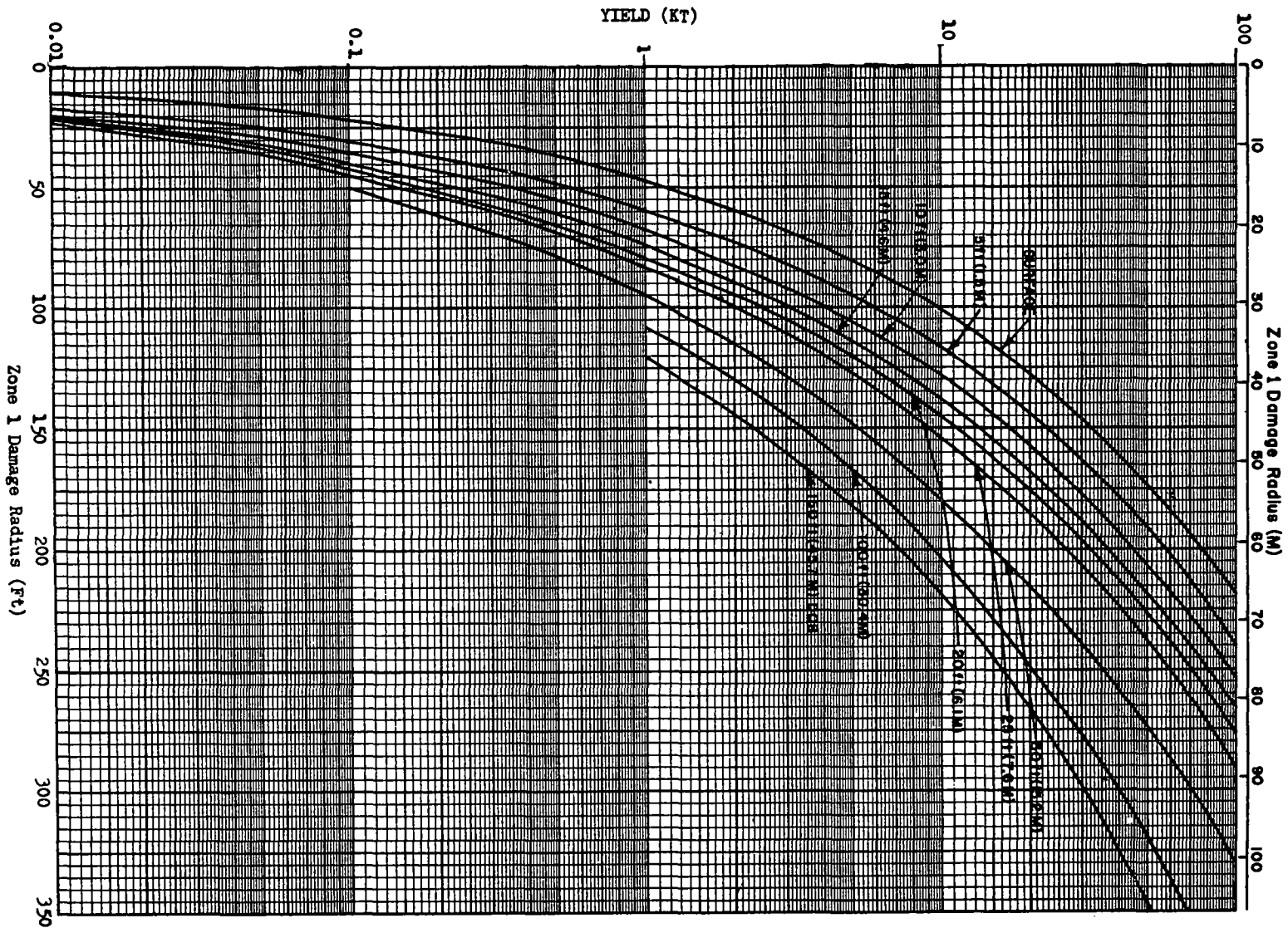
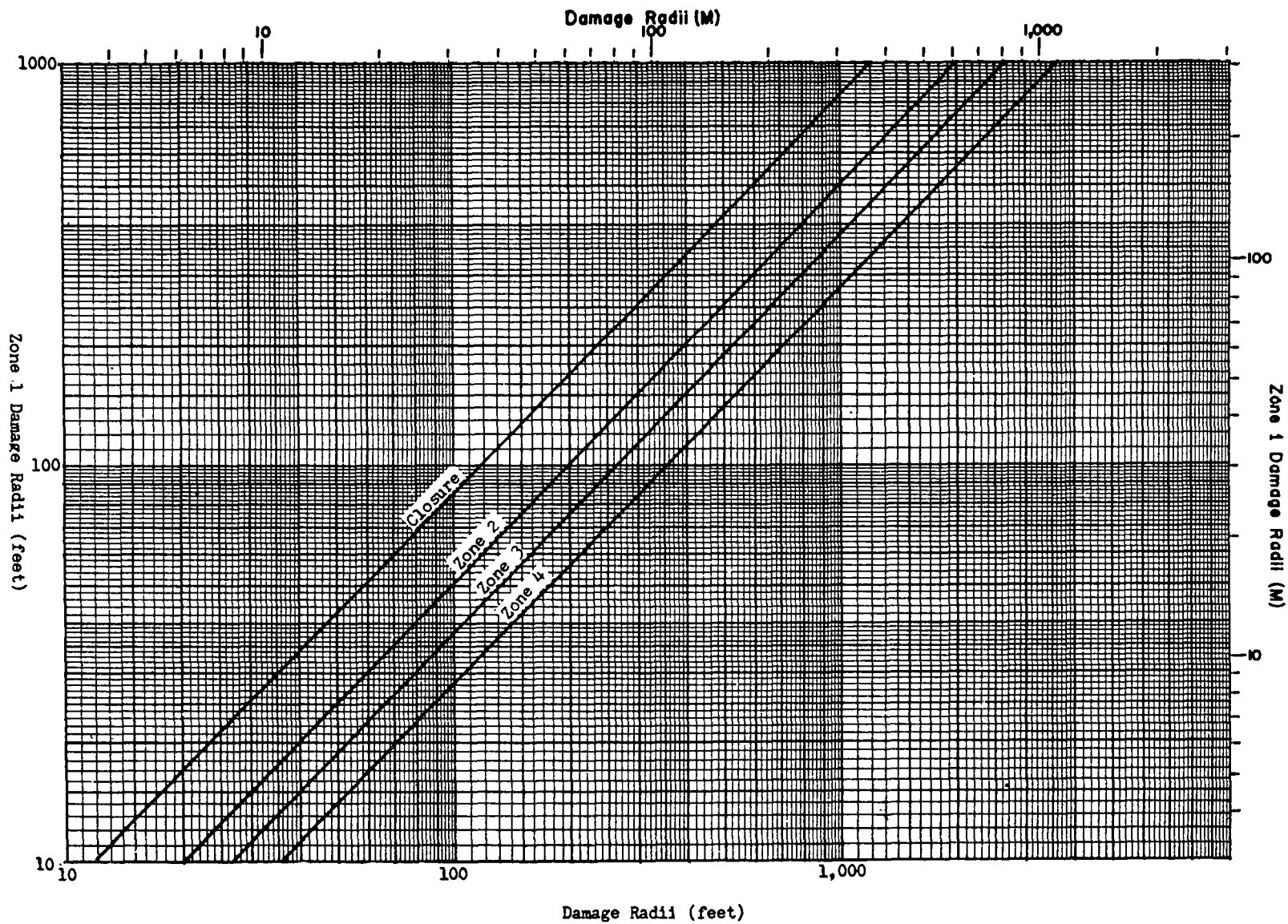


Figure 6-59. Depth of burst versus coupling factor.



★Figure 6-60. Yield versus zone 1 damage radii.



★Figure 6-61. Damage radii relationship.

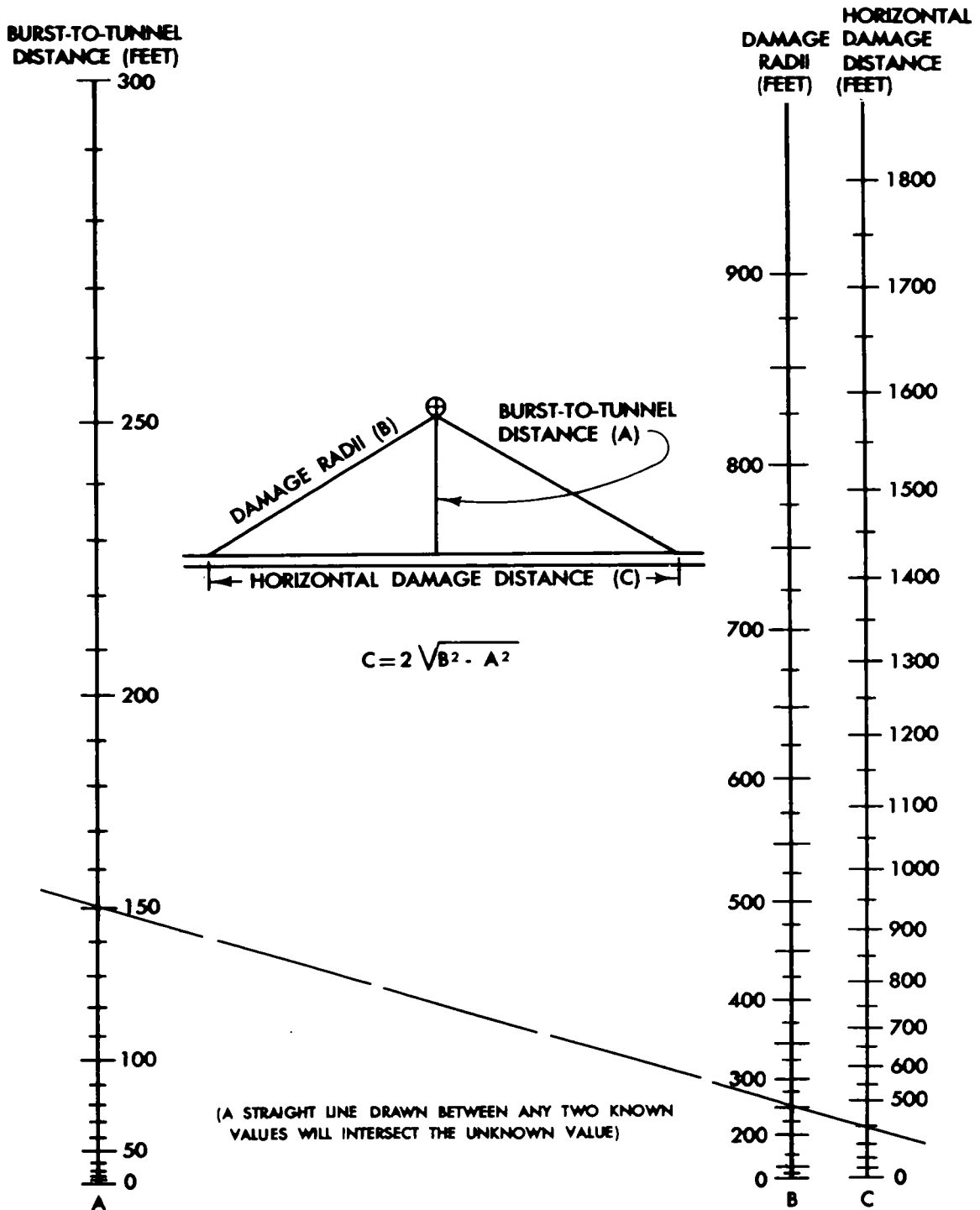


Figure 6-62. Nomograph for conversion of damage radii to horizontal damage distance.

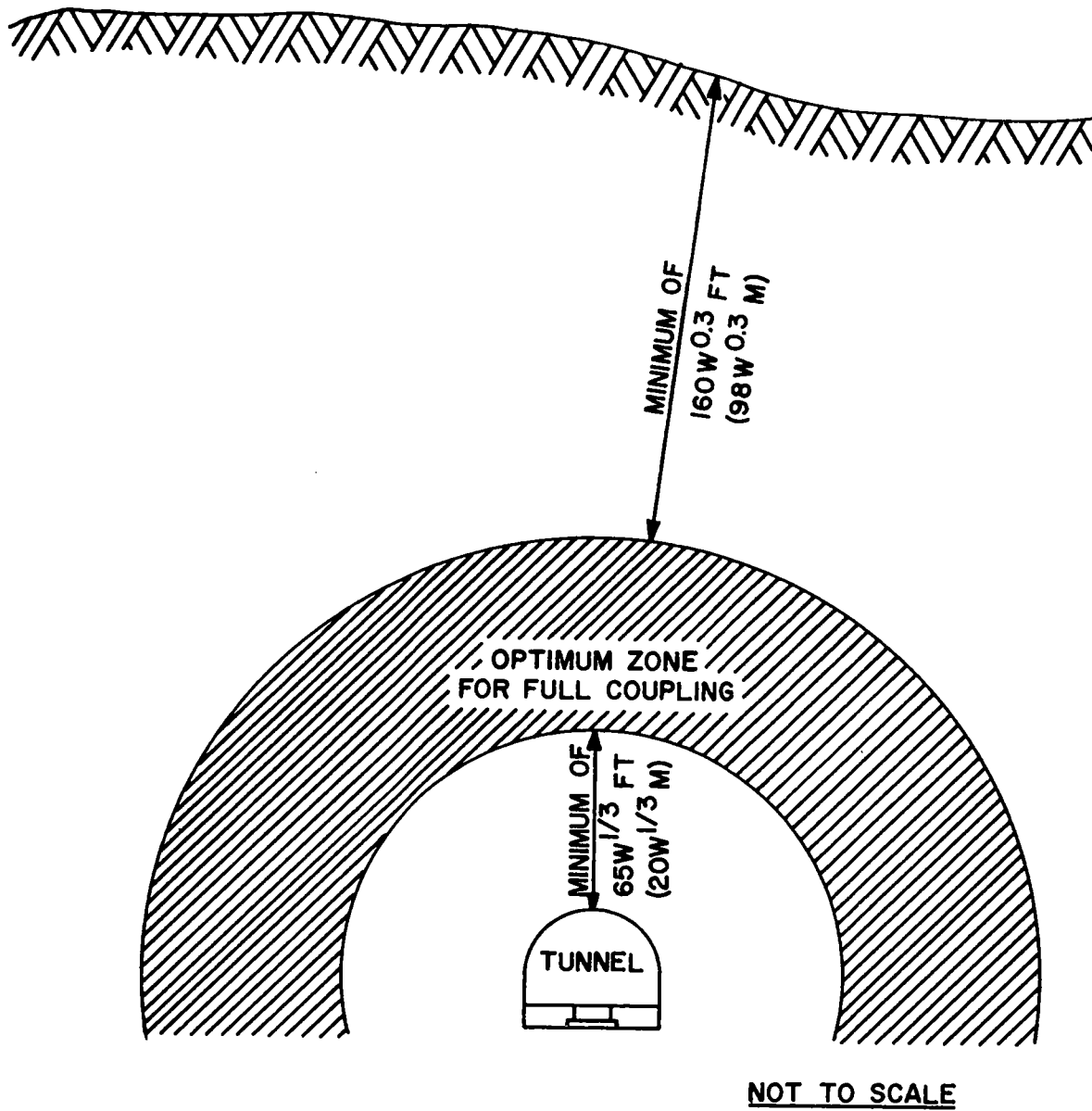


Figure 6-63. Optimum zone for full coupling.

6-39. Factors Affecting Damage for Bursts Not in Tunnel

a. Types of Media. The type of media through which the tunnel is bored affects the damage radii to some extent; however, scaled distances for contained shots in tuff and in granite are so close that correction is not warranted.

b. Tunnel Lining. Observed data do not indicate that normal tunnel linings appreciably affect damage; therefore, the data for unlined tunnels are used for all tunnels.

6-40. Burst Offset From Tunnel

ADM may be emplaced in shafts (adits) leading off from the tunnel. In such cases, the damage zones discussed previously for surface and underground bursts cannot presently be determined from data available. Minimum damage can be estimated, however, from the dimensions of an apparent crater in hard rock by equating the offset distance to the DOB. The limit of damage along the tunnel floor is estimated as being equal to that of the rupture zone (1.5 times crater radius). The apparent crater is smaller than estimated since a portion of the material which normally is blown out to form the crater is retained by the tunnel walls and becomes part of the radioactive debris. Emplacement procedures should include complete stemming of the emplacement shaft with at least 2 feet of sandbags or similar material.

6-41. Burst on Tunnel Floor

The damage caused by a nuclear explosion in an open tunnel has not been adequately determined; however, the minimum damage from a burst on the floor of a tunnel can be estimated in the same manner as outlined in the preceding case for tunnel offset emplacement using a zero DOB. Emplacement procedure on the tunnel floor includes the placing of sandbags over the ADM to provide tamping.

6-42. Residual Radiation

a. In Tunnel. At present, no method of estimating the intensity and duration of the residual activity in a tunnel damaged as a result of a nuclear explosion has been developed.

b. Fallout. The surface and underground detonation of ADM can cause militarily signifi-

cant fallout. The intensities and extent of contamination are dependent on yield, the depth at which the ADM is buried, and the degree of venting if detonated within a tunnel.

6-43. Post-Explosion Rock Temperature

Under certain conditions, the temperature of the rock in the immediate vicinity of the explosion can reach extremely high temperatures. This temperature rapidly subsides to the boiling point of water but may remain at that temperature for weeks.

6-44. Damage Criteria

a. Severe Damage. Severe damage is defined as that which requires standard tunneling procedures for rehabilitation or tunnel relocation. This is achieved through the use of surface or underground bursts (fig. 6-57; positions 1, 2, 3, and 4). The limit of zone 2 damage is the limit of severe damage.

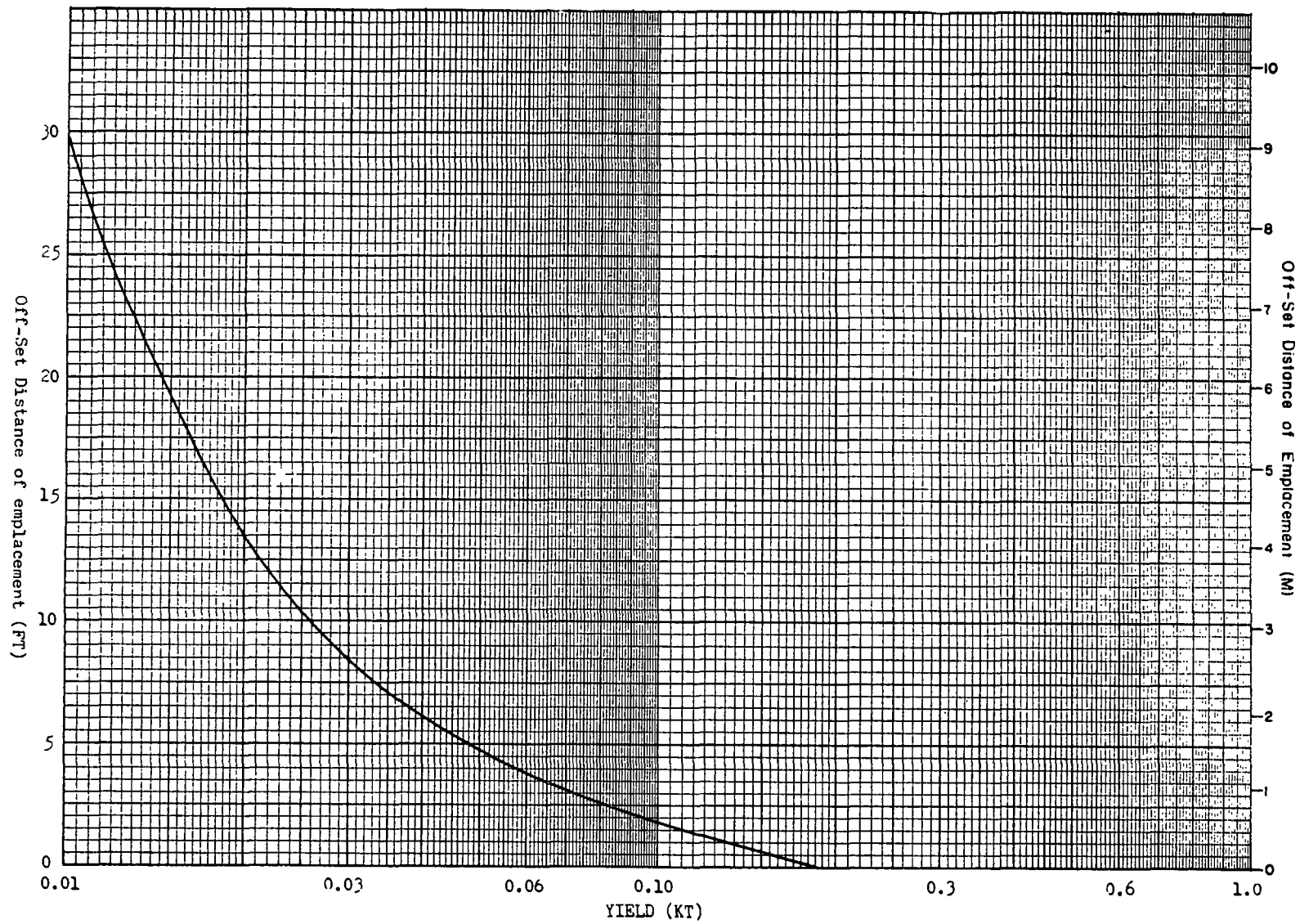
b. Moderate Damage. Moderate damage is defined as that which requires significant rehabilitation effort but does not call for standard tunneling procedures. However, these latter procedures may be necessary if the tunnel was originally driven through other than homogeneous rock. This level of damage is most easily achieved through use of tunnel offset or tunnel floor bursts (fig. 6-57; positions 5 and 6).

★*c.* A tunnel may be considered destroyed if it receives 100 feet (10 meters) of severe (Zone 2) damage. In lieu of other guidance, 100 feet of Zone 2 damage should be assumed for tunnel destruction.

6-45. Yield Determination

The first step in yield determination is the selection of the point at which the ADM is to be placed. Where possible, placement is far enough from the tunnel portals so that the limit of zone 4 damage is contained within the tunnel. If the tunnel length is insufficient, emplacement is at the midpoint. Additional damage may be achieved if the tunnel passes through a fault zone or similar nonstable geological conditions.

★*a. Surface Bursts.* Yield determination for surface bursts (fig. 6-57; positions 1 and 2) is accomplished by first determining the burst to tunnel distance and the horizontal damage dis-



★Figure 6-64. Offset distance of emplacement versus yield to block 100 feet (30 meters) of tunnel.

tance. Unless otherwise directed, criteria for tunnel destruction is 100 feet (30 meters) of Zone 2 (severe) damage. Determine the damage radius from figure 6-62. Enter figure 6-58 with the damage radius, read across to the curve representing Zone 2 damage, and read down to select the required yield.

★*b. Underground Bursts* (fig. 6-57; positions 3 and 4). Yield determination is made as follows:

(1) Find the burst to tunnel distance, considering the depth of burial.

(2) Find the damage radius from figure 6-62. If the horizontal damage distance is not given, assume 100 feet (30 meters) of Zone 2 damage.

(3) Convert this damage radius to Zone 1 damage radius using figure 6-61.

(4) Determine the yield required from figure 6-60, using the Zone 1 damage radius and the depth of burial.

c. Offset Bursts (fig. 6-57; position 5). Yield determination is made by entering figure 6-64 with the offset distance of emplacement, reading over to the curve and down to yield.

d. Bursts on Tunnel Floor (fig. 6-57; position 6). Enter figure 6-64 with zero offset distance and read yield of 0.186 kt. For this emplacement mode, this yield is constant unless the damage criterion is changed.

6-46. Illustrative Examples

a. Surface Emplacement Directly Over Tunnel (fig. 6-65).

Given: Burst to tunnel distance—100 feet.

Find:

(1) Minimum yield required to maximize Zone 2 damage.

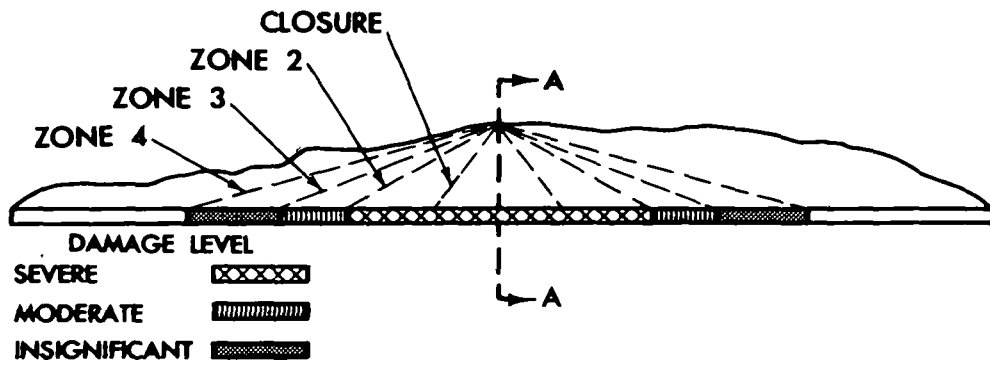
(2) Determine length of tunnel receiving at least moderate damage (extent of Zone 3 damage).

Solution:

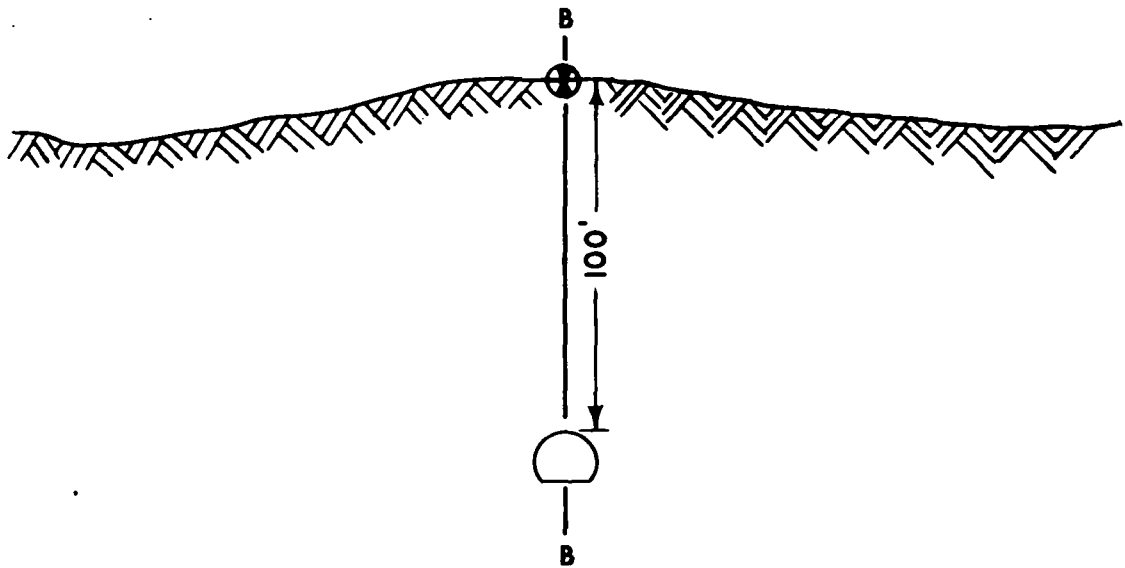
(1) *Minimum yield required to achieve desired damage.* Enter figure 6-60 with zone 1 radius (burst to tunnel distance) of 100 feet, read up to surface curve, and over to yield of 10 kt.

(2) *Length of tunnel receiving at least moderate damage.* Assuming that a 10 kt ADM is available, enter figure 6-61 with zone 1 radius of 100 feet, read over to Zone 3 curve (limit of moderate damage), and down to radius of 265 feet. On nomograph in figure 6-62, use a straightedge to connect burst to tunnel distance to 100 feet on scale A and Zone 3 radius of 265 feet on scale B. Extension of this line crosses scale C at a horizontal damage distance of 500 feet (151 meters), which is the length of tunnel receiving at least moderate damage.





a. LONGITUDINAL PROFILE B-B



b. SECTION A-A

Figure 6-65. Surface emplacement directly over tunnel.

b. Surface Emplacement NOT Directly Over Tunnel (fig. 6-66).

Given: An emplacement site for a surface burst has a burst to tunnel distance of 144 feet. An ADM with yield of 50 kt is available.

Find:

- (1) Maximum degree of damage received by tunnel.
- (2) Length of tunnel receiving this damage.

Solution:

- (1) *Maximum degree of damage.* Enter

left ordinate of figure 6-58 with burst to tunnel distance of 144 feet. This line intersects with 50 kt within zone 1 (severe damage).

- (2) *Length of tunnel receiving severe damage.* Figure 6-58 shows that 50 kt causes zone 2 (severe damage) out to a radius of 350 feet. Enter scale A of nomograph in figure 6-62 with 144 feet; lay straightedge through this point and through 350 feet on scale B; and read on scale C horizontal damage distance of 625 feet (191 meters).

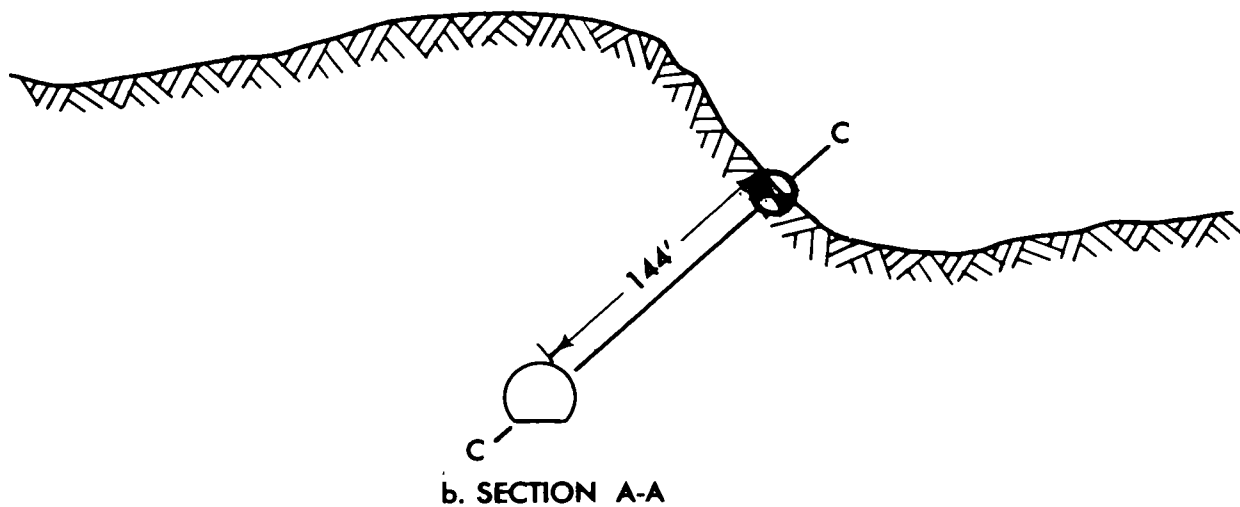
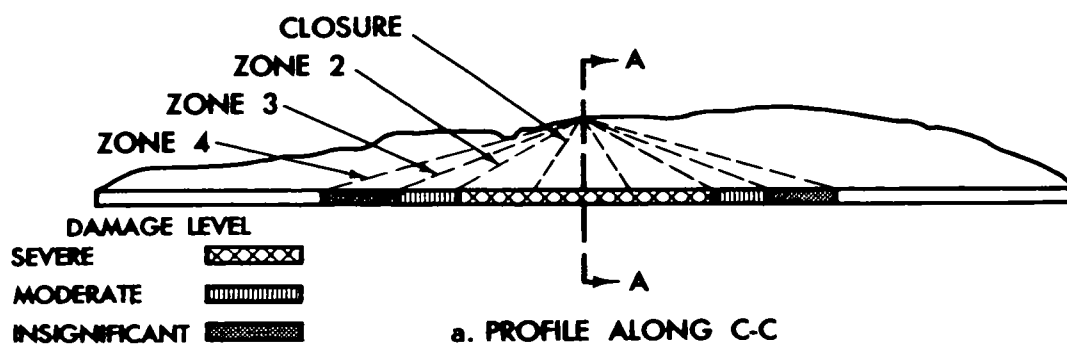


Figure 6-66. Surface emplacement NOT directly over tunnel.

c. Underground Emplacement Directly Over Tunnel (fig. 6-67).

Given: Depth of burial—40 feet. Burst to tunnel distance—140 feet.

Find:

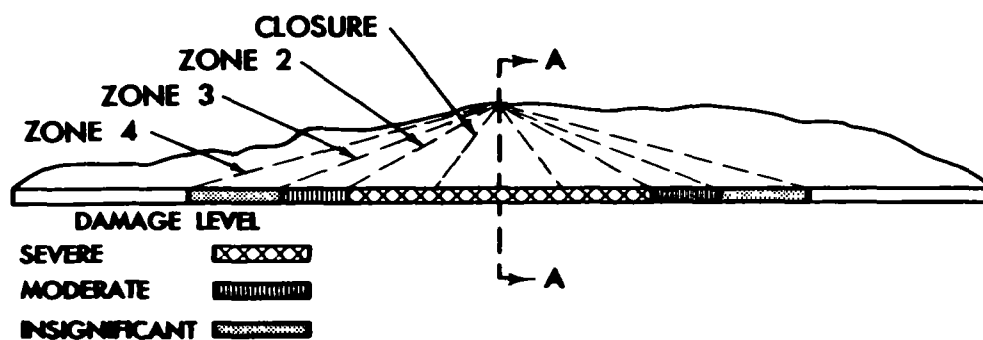
- (1) Minimum yield required to achieve zone 1 damage radius tangent to tunnel.
- (2) Length of tunnel receiving severe damage.

Solution:

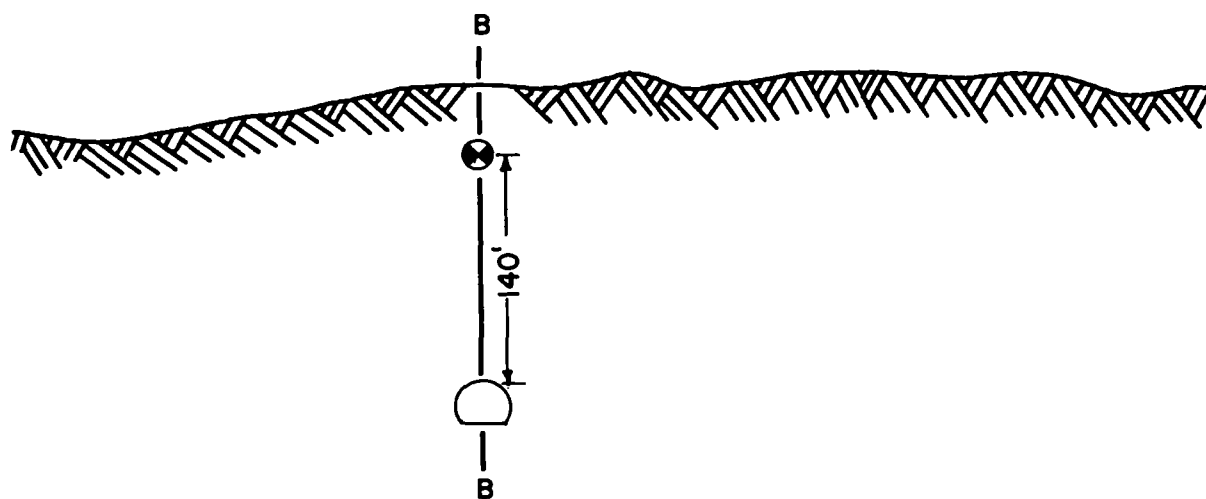
- (1) *Minimum yield to achieve desired damage.* Enter figure 6-60 with zone

1 radius (burst to tunnel distance) of 140 feet, read up to DOB of 40 feet, and over to yield of approximately 5 kt.

- (2) *Length of tunnel receiving severe damage.* Enter figure 6-61 with zone 1 radius of 140 feet, read over to zone 2 (limit of severe damage), and down to radius of 275 feet. Enter scale A of nomograph in figure 6-62 with burst to tunnel distance of 140 feet. Connect this point with zone 2 damage radius of 275 feet on scale B. Extend this line to cross scale C at 460 feet (140 meters), which is the length of tunnel receiving severe damage.



a. LONGITUDINAL PROFILE B-B



b. SECTION A-A

Figure 6-67. Underground emplacement directly over tunnel.

d. Underground Emplacement NOT Directly Over Tunnel (fig 6-68).

Given: Burst to tunnel distance — 148 feet.
Available ADM—10 kt.

Find: Depth of burial to achieve zone 1 radius tangent to tunnel.

Solution: Enter figure 6-60 with zone 1 radius (burst to tunnel distance) of 148 feet and yield of 10 kt. These intersect at DOB of approximately 22 feet (7 meters).

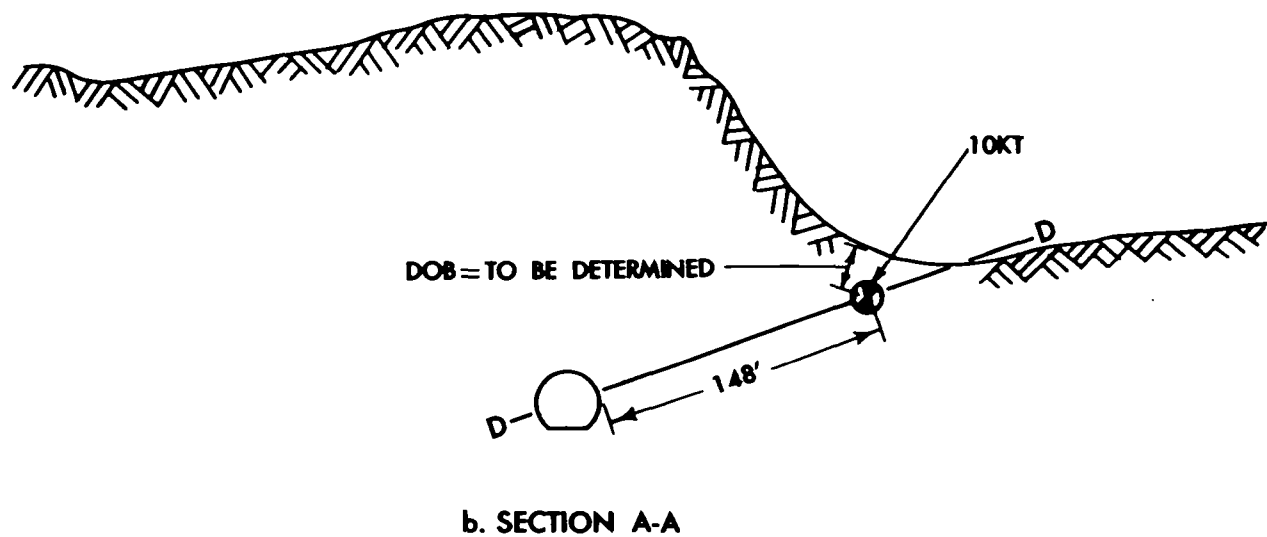
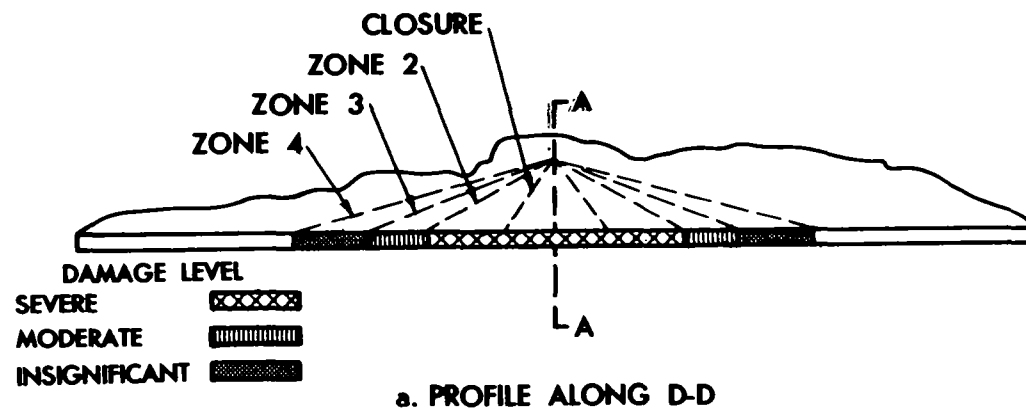


Figure 6-68. Underground emplacement NOT directly over tunnel.

e. Tunnel Offset Burst (fig. 6-69).

Given: Offset distance of emplacement 13.5 feet. Required damage is 100 feet of rupture along tunnel floor.

Find: Required yield.

Solution: Enter figure 6-64 with 13.5 feet offset distance, read over to curve, and down to a required yield of at least 0.02 kt.

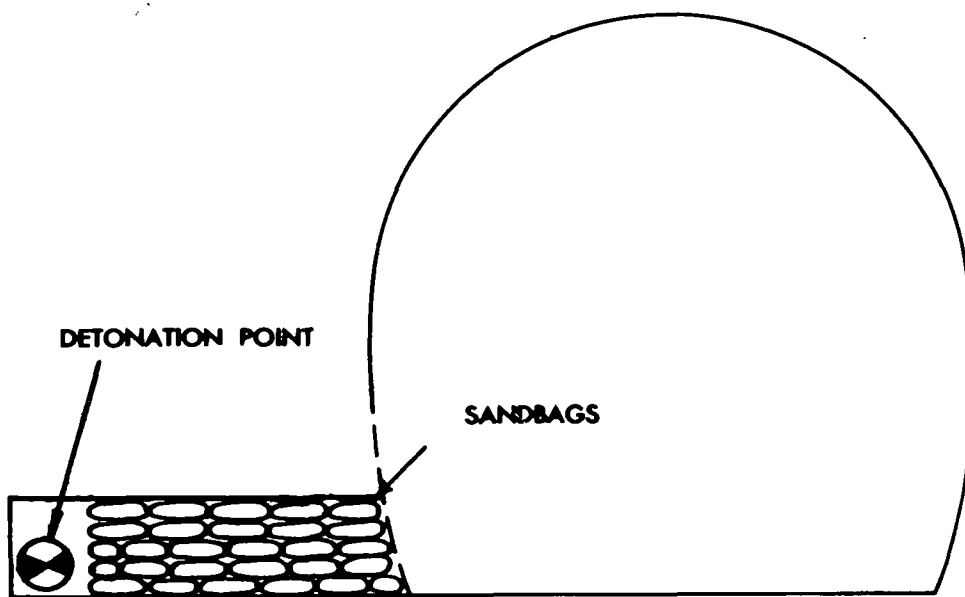


Figure 6-69. Tunnel offset emplacement.

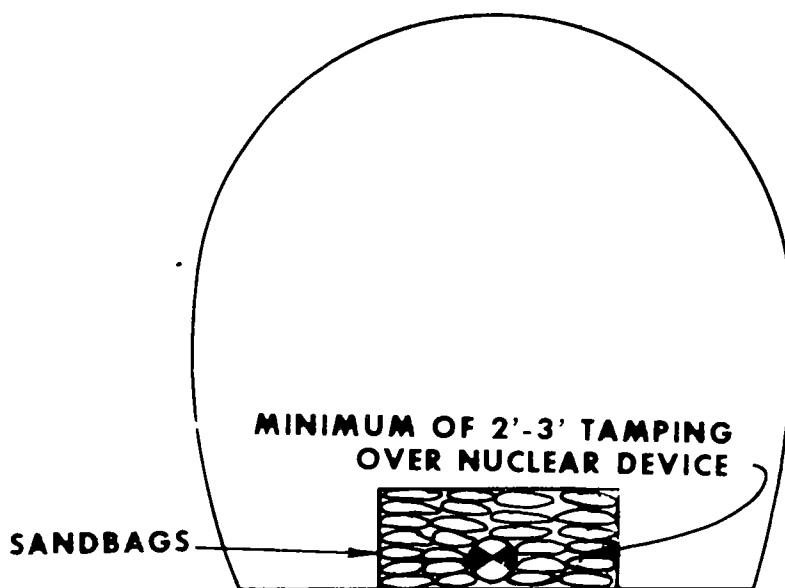


Figure 6-70. Emplacement on tunnel floor.

f. Emplacement on Tunnel Floor (fig. 6-70).
Given: Required damage is 100 feet of rupture along tunnel floor.

Find: Required yield.

Solution: Enter figure 6-64 with zero offset distance and read constant yield of 0.186 kt.

6-47. Underwater Tunnels

a. Damage Criterion. Flooding is the desired level of damage in destruction of an underwater tunnel. In order to achieve flooding, it is necessary to breach the tunnel casing and the overburden to allow the water to force itself into the tunnel.

b. Placement of ADM. Two emplacement positions are possible for nuclear demolition of an underwater tunnel. Normally, the ADM is placed in the tunnel against the roof, however, if access to the tunnel is not possible, then the ADM may be emplaced on the river or harbor bottom directly over the tunnel.

c. Radioactivity. Radiation resulting from nuclear demolition of underwater tunnels cannot be predicted at present with any degree of certainty. It is possible that radioactive material will be blown out either end of the tunnel

together with fallout and base surge contamination.

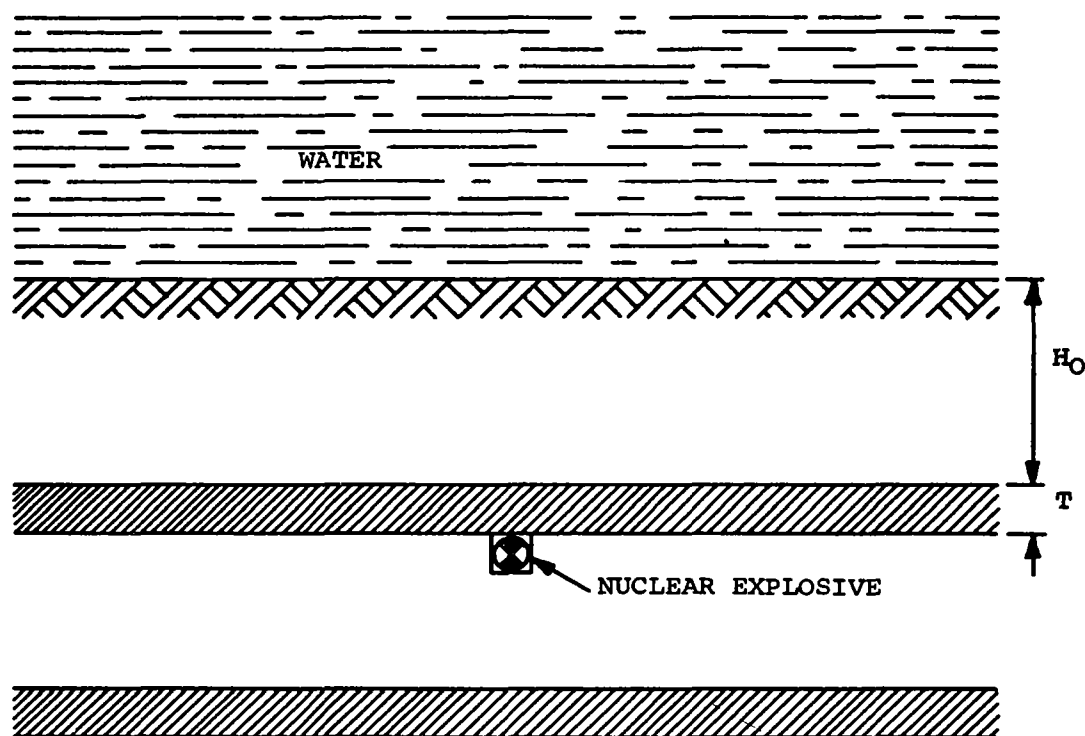
6-48. Placement in Tunnel

By placing an ADM against the inside top of an underwater tunnel, breaching of the tunnel casing and the overburden is achieved in the same manner as described for an ADM emplaced on the downstream side of a gravity dam.

a. Rock Overburden. If the tunnel is under rock, then the tunnel casing, which usually is reinforced concrete, and the overburden can be considered as the same material.

b. Other Than Rock Overburden. This terminology is used for overburden of all type soils that might be encountered on river or harbor bottoms: sand, clay, silt, muck, or in any combination. Crater dimensions for a given yield in hard rock (concrete) are about one-half those in saturated soils; therefore, it is assumed valid to use one-half the height of overburden ($\frac{1}{2} H_0$) for yield determination where other than rock overburden exists.

c. Yield Determination. Figure 6-72 enables rapid determination of required yield by giving



$$\text{Required Damage Distance} = H_O + T$$

Where

H_O = Height of Overburden

T = Thickness of Tunnel Casing

Figure 6-71. Achievement of damage to underwater tunnel by placement of nuclear explosive inside tunnel.

the required damage distance as a function of yield. Simply enter with the appropriate distance according to type of overburden, ($H_O + T$) or ($1/2 H_O + T$), then read over to the curve and down to the yield.

6-49. Placement on River or Harbor Bottom

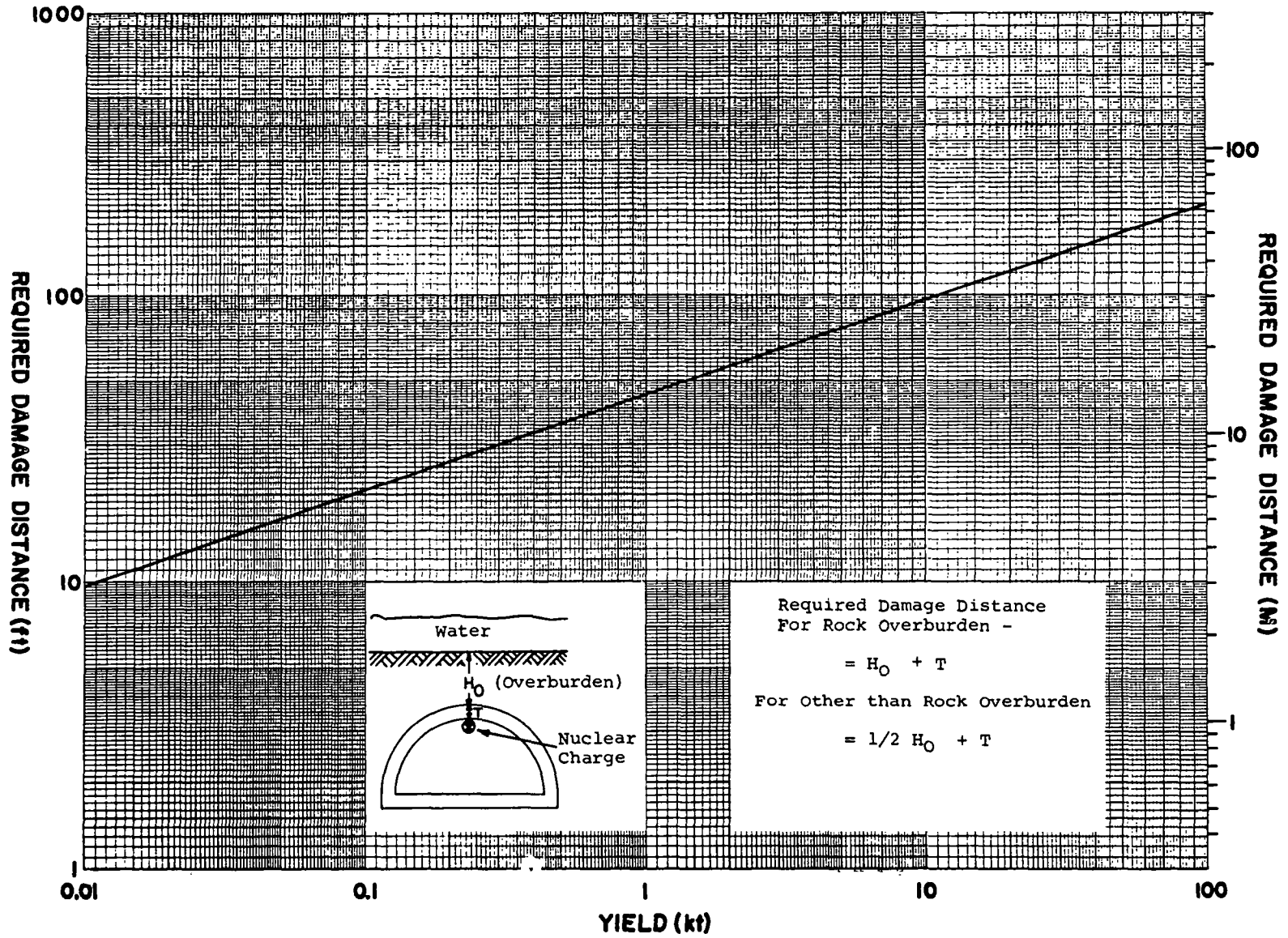
This emplacement mode achieves flooding of the tunnel by cratering action in the overburden. As the amount of overburden increases, rupture of the tunnel casing may be accomplished by spalling. The radius of Zone 1 damage, as with underground tunnels, becomes the yardstick for yield determination. Zone 1 damage radius is equal to the burst to tunnel distance.

For underwater tunnels this burst to tunnel distance is equal to the height of overburden (H_O) plus thickness of the tunnel casing (T). Computation of the burst to tunnel distance also takes into account the depth of burial or depth of water in this case. These computations are accomplished in figures 6-73 and 6-74 which give burst to tunnel distances for varying depths of crater as a function of yield for rock and other than rock overburden, respectively.

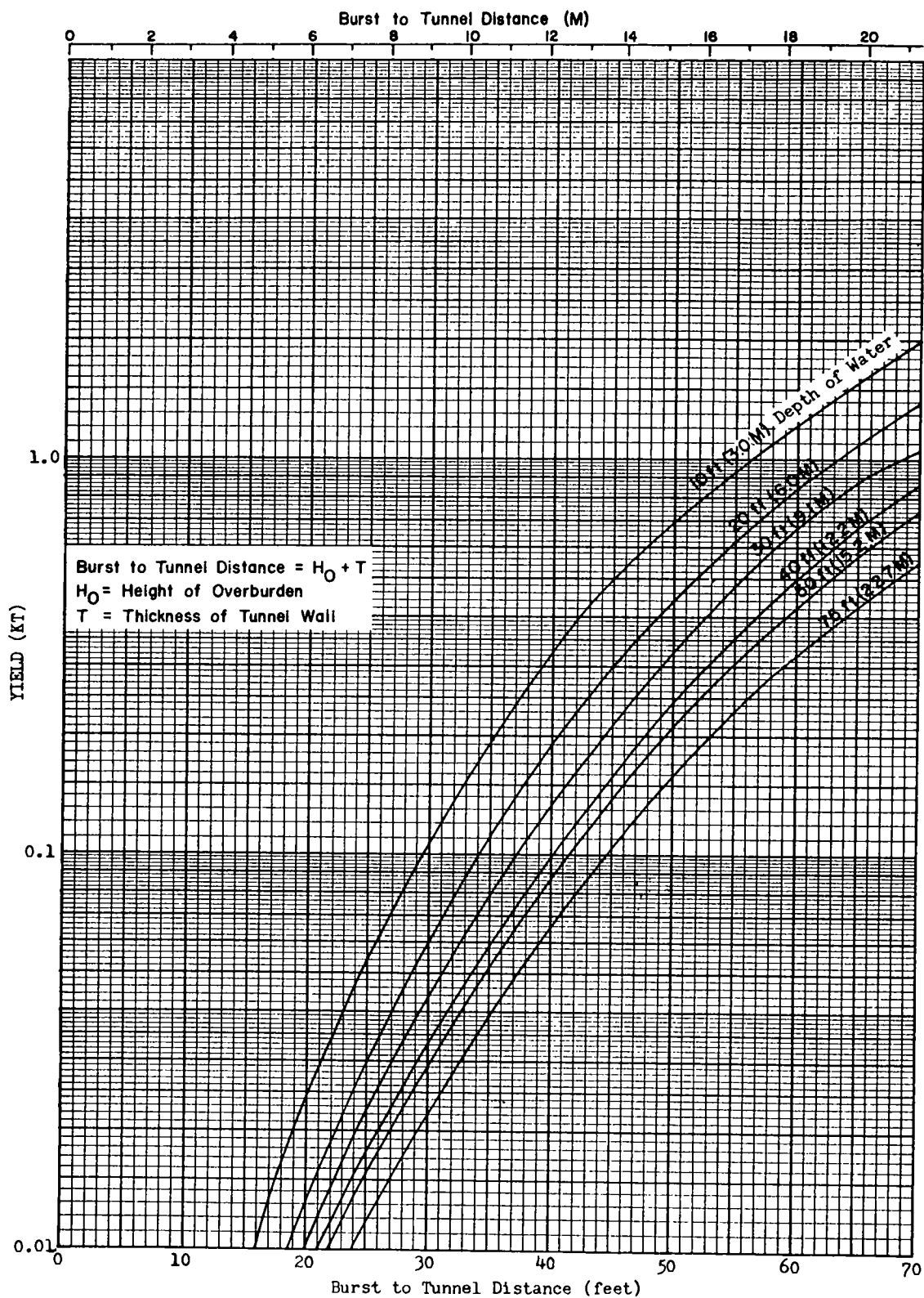
6-50. Illustrative Examples

★a. *Placement Inside Tunnel With Rock Overburden.*

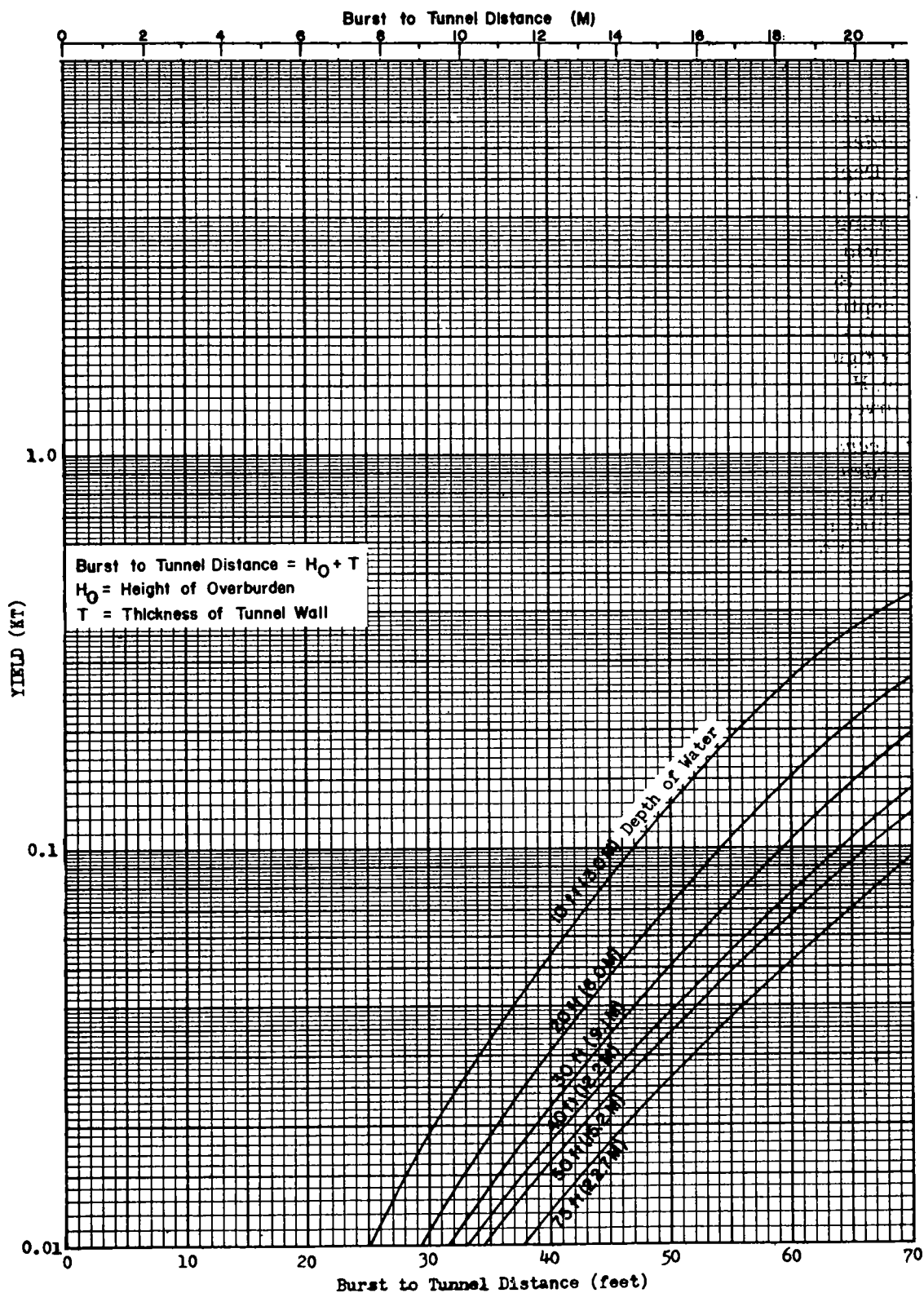
Given: Depth of water—20 feet. Depth of rock



★Figure 6-72. Required damage distance versus yield for burst in tunnel.



★Figure 6-73. Yield versus burst to tunnel distance for varying depths of water (rock overburden).



★Figure 6-74. Yield versus burst to tunnel distance for varying depths of water (other than rock overburden).

overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Yield required to flood tunnel.

Solution: Since placement is inside tunnel, the depth of rupture concept is applicable with rock overburden. Enter figure 6-72 with required damage distance, $H_o + T = 15 + 4 = 19$ feet, read over to curve, and down to yield of 0.078 kt.

b. Placement on Bottom of River With Rock Overburden.

Given: Depth of water—20 feet. Depth of rock overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Required yield.

Solution: Burst to tunnel distance = $H_o + T = 19$ feet. Enter figure 6-73 (rock overburden) with burst to tunnel distance of 19 feet, read up to 20-foot depth of water, and over to yield of 0.011 kt.

★*c. Placement Inside Tunnel With Other Than Rock Overburden.*

Given: Depth of water—20 feet. Depth of overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Required yield.

Solution: $\frac{1}{2} H_o + T = 7.5 + 4 = 11.5$ feet. Enter figure 6-72 with 11.5 feet. Enter figure 6-72 with 11.5 feet, read over to curve, and down to yield of 0.017 kt.

d. Placement on River Bottom With Other Than Rock Overburden.

Given: Depth of water—20 feet. Depth of overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Required yield.

Solution: Burst to tunnel distance = 19 feet. Enter figure 6-74 with burst to tunnel distance of 19 feet. An answer cannot be read therefore yield of 0.01 kt may be used.

Section VII. AIRFIELDS

6-51. General

a. The most effective way to destroy the operational capabilities of an airfield is to demolish the runway complex. The runway complex is the single, indispensable element of any field. Supporting facilities such as hangars, shops, warehouses, and communication equipment are relatively easy to replace or are not absolutely essential for emergency operations.

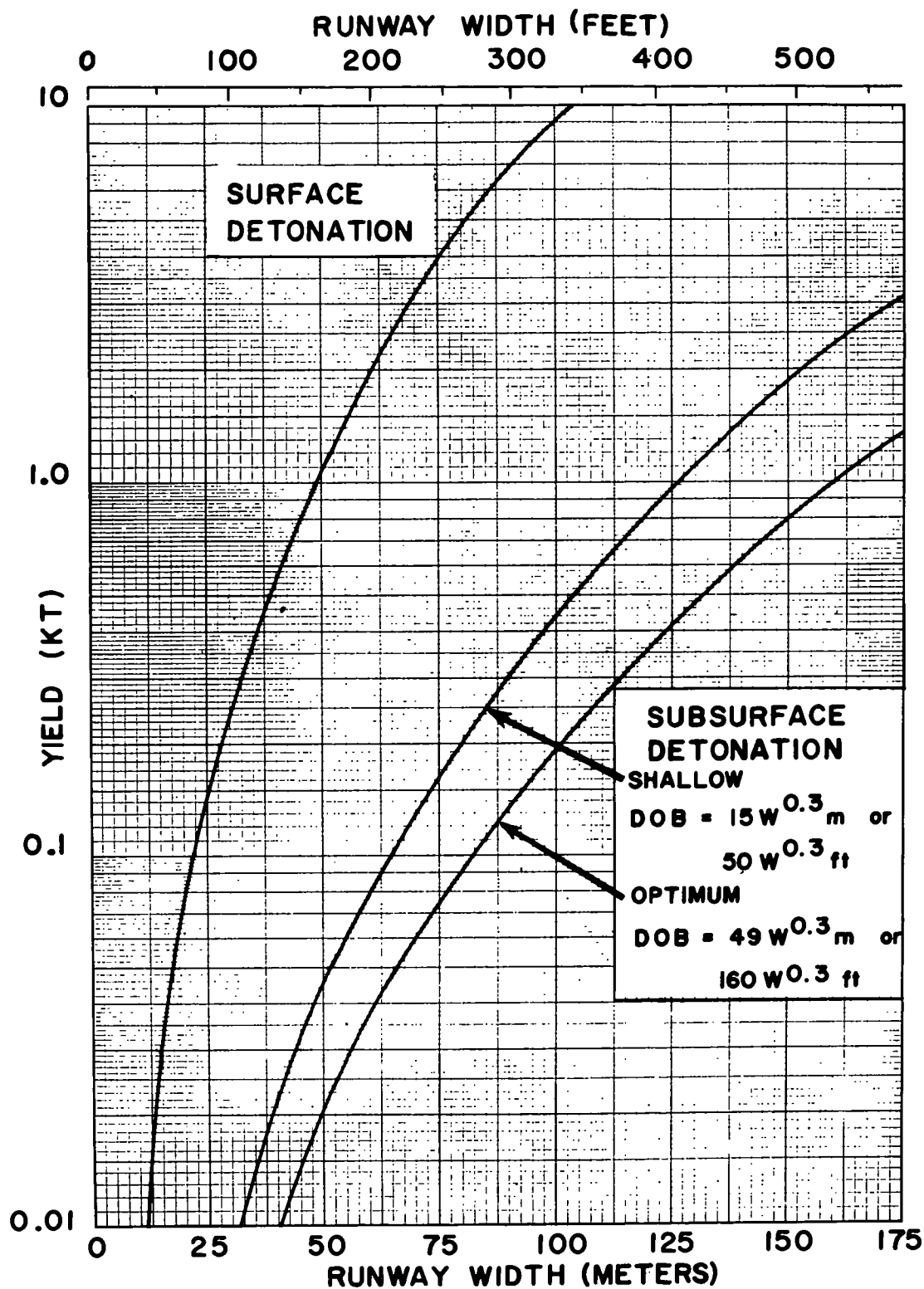
b. Since runway characteristics vary for different airfields, the ADM emplacement locations required for destruction of a specific runway complex depend on the size, layout, and importance of the particular airfield. The following paragraphs discuss the general method of approach for using atomic demolition munitions as cratering charges to destroy the operational capabilities of runways.

6-52. Emplacement Criteria

a. The destruction of an airfield runway complex generally requires multiple-charge detonations. One of the most important factors which must be considered in developing emplacement criteria is the minimum separation distance required between atomic demolition munitions to prevent the first detonation from damaging an adjacent munition. The separa-

tion distance for the hypothetical family of ADM is 1000 meters (3300 feet) for surface bursts. Occasionally, the requirement of separation distances can be overcome by detonating one device and returning at a later time to emplace and detonate the other. However, the level of radioactivity released to the atmosphere by the detonation of the first ADM places a significant limitation on reentry capabilities for emplacing and detonating subsequent ADM.

b. Also important in determining emplacement locations is the degree of destruction desired with regard to supporting facilities and the runway complex. The detonation of any ADM on the runway denies immediate use of the airfield to nearly all types of aircraft because of local radioactivity levels and debris created by the explosion. For long-term denial, however, the runway complex must be analyzed to determine the most effective placement of ADM to insure that the maximum continuous length of undamaged runway remaining after device detonation is less than the length required for takeoff and landing of a given aircraft.



★Figure 6-75. Yield selection criteria for runway demolition.

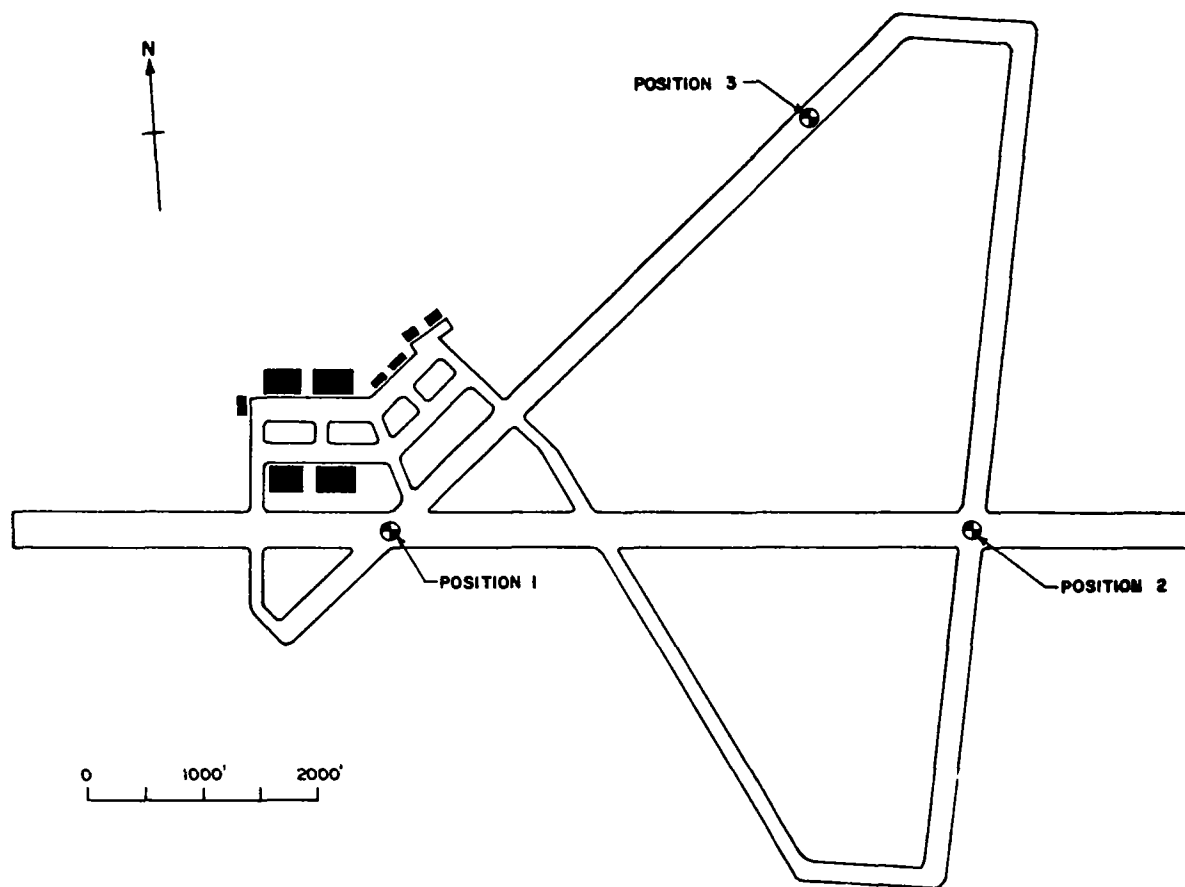


Figure 6-76. Airfield layout and ADM emplacement positions for illustrative example.

6-53. Yield Selection

a. *General.* The yield required to crater a runway depends on the depth of burst of the ADM, the width and thickness of the runway, and the characteristics of the subgrade material on which the runway is constructed. The yield and depth of burst is selected so that the diameter of the rupture zone along the surface is at least equal to the runway width.

b. *Surface Emplacement.*

(1) If the operational situation precludes burial of the ADM beneath the runway or in drainage culverts or utility ducts under the runway, it is necessary to detonate the munitions on the surface of the runway.

(2) The selection of the yield required to crater a runway is complicated by the fact that several types of material—the concrete run-

way and the subgrade material—must be cratered.

(3) For surface detonations the scouring mechanism contributes significantly to crater formation. Since concrete is more resistant to scour than soil, the size of the crater plus rupture zone resulting from a surface burst on a concrete slab overlaying soil is expected to be greatly influenced. Concrete is used, therefore, as the governing medium for determining crater dimensions for surface and near surface bursts on runways. Figure 6-75 gives a curve for determining surface burst yield requirements for varying widths of runway. The curve is based upon cratering in hard rock.

★c. *Subsurface Emplacement.* For subsurface detonations other than near surface

bursts, the concrete runway slab has little effect on the dimensions of the crater produced. Even for shallow depths of burst the concrete slab is thin compared to the depth of burial, and the higher strength and density of the concrete does not greatly influence the size of the crater. The governing medium for subsurface detonations, therefore, is the subgrade material which is assumed to have cratering characteristics similar to desert alluvium. Figure 6-75 gives curves, based on cratering experience in dry soil, for determining runway cratering yield requirements for a depth of burst of $50 W^{0.3}$ ft ($15 W^{0.3}m$) and $160 W^{0.3}$ ft ($49 W^{0.3}m$). Should these depths exceed emplacement capability the procedures outlined in paragraph 6-8 are followed based on the maximum depth attainable.

★*d. Illustrative Example.* The following example illustrates the recommended procedure for determining the yield requirements, depth of burst, and emplacement locations for demolition of runways.

Given: Figure 6-76 shows the layout of an airfield designed to handle heavy jet bombers. A demolition mission is planned with the objective of denying the use of the runway facilities for jet bombers and fighters. The maximum continuous length of undamaged runway which can remain after the demolition mission and accomplish the objective is 4900 feet (1500 meters).

Find: The ADM yields and emplacement positions for detonation at the surface and at depths of burst of $50 W^{0.3}$ feet and $160 W^{0.3}$ feet. For the subsurface detonations determine the depth of burst. Assume a minimum separation distance of 3300 feet (1000 meters) for multiple ADM surface detonations.

Solution:

(1) *Emplacement positions.* The location of the ADM on the runway complex is the same for surface and subsurface detonation. Analysis of the runway layout indicates that a minimum of three ADM (identified as positions 1, 2, and 3 in fig. 6-76) are required to deny all runways. Detonation of ADM at positions 1 and 2 reduces the undamaged length of the main east-west runway and the north-south runway to less than 4900 feet. A detona-

tion at position 3, together with the detonation at position 1, reduces the undamaged length of the SW-NE runway to less than 4900 feet.

(2) *Yield selections—surface detonations.*

(a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for surface burst and runway width of 300 feet, yield required is 7.0 kt.

Answer: Use ECHO/10 kt (table 3-1).

(b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for surface burst and runway width of 200 feet, yield required is 2.0 kt.

Answer: Use DELTA/5 kt (table 3-1).

(3) *Yield selection—subsurface detonations (depth of burst of $50 W^{0.3}$ ft).*

(a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for DOB = $50 W^{0.3}$ ft and runway width of 300 feet, yield required is 0.32 kt.

Answer: Use ALPHA/0.5 kt (table 3-1).

$$\text{DOB} = 50 (0.5^{0.3}) \text{ ft} = 50 (0.81) = 40.5 \text{ ft}$$

(b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for DOB = $50 W^{0.3}$ ft and runway width of 200 feet, yield required is 0.082 kt.

Answer: Use VICTOR/0.1 kt (table 3-1).

$$\text{DOB} = 50 (0.1^{0.3}) \text{ ft} = 50 (0.5) = 25 \text{ ft}$$

(4) *Yield selection—subsurface detonations (depth of burst of $160 W^{0.3}$ ft).*

(a) Positions 1 and 2: Width of E-W runways = 300 feet (governing width). Referring to figure 6-75 for DOB = $160 W^{0.3}$ ft and runway width of 300 feet, yield required is 0.14 kt.

Answer: Use WHISKEY/0.3 kt (table 3-1).

$$\text{DOB} = 160 (0.3^{0.3}) \text{ ft} = 160 (0.7) = 112 \text{ ft}$$

(b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for DOB = $160 W^{0.3}$ ft and runway width of 200 feet, yield required is 0.042 kt.

Answer: Use UNIFORM/0.05 kt (table 3-1).

$$\text{DOB} = 160 (0.05^{0.3}) \text{ ft} = 160 (0.41) = 66 \text{ ft}$$

(5) *Summary of yield requirements.*

Position No.	Yield Required		
	Surface	Subsurface	
		DOB=160 W ^{0.3} ft	DOB=50 W ^{0.3} ft
1	10 kt	0.5 kt	0.3 kt
2	10 kt	0.5 kt	0.3 kt
3	5 kt	0.1 kt	0.05 kt

The yield requirements listed above are indicative of the advantage to be gained by subsurface emplacement as compared to surface bursts. Furthermore, the radioactivity released

from the subsurface detonation would be significantly reduced compared to the surface bursts because the total yield requirements for subsurface detonations are much smaller than for surface bursts. In addition, the fraction of radioactivity released to the atmosphere by a subsurface detonation at optimum depth of burial (49 W^{0.3} m or 160 W^{0.3} ft) is reduced by over 85 percent of that of a surface detonation of the same yield.

Section VIII. MISCELLANEOUS ADM TARGETS

6-54. General

Special target analysis techniques for ADM in which cratering for point targets is the governing effect were discussed in paragraphs 6-3 through 6-53. It should not be forgotten, however, that ADM have a mass destruction capability and are suitable for employment on targets susceptible to nuclear effects other than cratering. Moreover, target analysis is not complete until the target area is analyzed for contingent effects. Either the visual or numerical method of target analysis is applicable for analyzing area targets utilizing the damage tables and contingent effects tables in appendix II or FM 101-31-2. This section discusses in general terms other targets appropriate for ADM attack in which the cratering effect may not govern.

★6-55. Railroad Marshaling Yards

A railroad marshaling yard is an area target susceptible to blast and cratering effects. Repair facilities, roundhouses, engine sheds, and rolling stock are primarily damaged by blast while turntables and switching facilities are most effectively damaged by cratering. In cratering a railroad yard, the depth of crater is less important than width since any significant disruption of the rails requires major rehabilitation. Blast damage criteria for various yields are shown in the damage tables; cratering data may be obtained from paragraphs 6-3 through 6-14. In populated areas, subsidence craters should be considered to preclude all nuclear effects to local inhabitants.

6-56. Ports

a. There are two general methods by which port facilities may be denied. The first is to use one or more large yield ADM to demolish the entire port as an area target. The second method is to employ a number of small yield ADM to destroy key port installations. The method of employment is, of course, dependent on the layout and size of the ports and the number and type of ADM available.

b. If one or more large yield ADM are used to attack the entire port as a single target, many of the facilities most essential to the port's operation, such as wharves and tidal locks, will remain largely undamaged. Above ground structures and equipment susceptible to blast and thermal effects will be damaged in accordance with the yield and distance from ground zero. Fires, mostly of secondary origin, will contribute to destruction. Since this method of attack destroys only those facilities near ground zero, it will hinder but not completely deny the use of a large port. The principal advantages of this method are the economy of ADM employed and the short time and little effort required for preparation.

c. If the second method is employed, a number of relatively small yield ADM consistent with separation distances may be selectively emplaced to demolish key harbor installations. Some of these facilities, such as the road and rail net serving the port, have already been discussed. Only those facilities peculiar to port operations are discussed below.

(1) The wharves are essential to port operations. Destruction of all the wharfage, therefore, completely denies the use of the port for an extended period. However, total destruction requires the use of numerous ADM and extensive emplacement effort. There are two general types of wharf construction: deck docks supported by piles, which are susceptible to blast and thermal effects; and quay walls made from concrete or masonry, which are best attacked utilizing the cratering effect prescribed for concrete dams or bridges (para 6-15 through 6-30).

(2) Tidal locks are necessary in some ports to maintain an adequate depth of water in the harbor area. Such facilities are attacked in a fashion similar to that prescribed for canal locks (para 6-31 through 6-33).

(3) Breakwaters are frequently necessary to protect wharf areas from wave action. Creating a large enough gap in a breakwater will handicap operations at the wharves but will rarely deny use of any of them. If it is desired to breach breakwaters, however, techniques similar to those prescribed for breaching gravity dams are applicable (para 6-23 through 6-30).

(4) The destruction of ship repair facilities is not considered here but rather under industrial plants. Methods of destroying drydocks, however, are comparable to the techniques prescribed for canal locks (para 6-31 through 6-33).

d. Only by destruction of the wharves can a port be denied for an extended period of time. However, demolition of wharves generally require a large number of ADM which may result in overdestruction in the port area and a

radiation hazard to the surrounding population.

6-57. Industrial Plants and Power Facilities

a. The use of ADM permits rapid and long term denial of industrial and power installations; however, such plants are usually located in or near heavily populated areas. As a consequence, it may be necessary to limit overdestruction and confine radiation. Each industrial facility must be analyzed separately to determine the best method of denial. Two general approaches are available in attacking a large installation. One relatively large yield ADM may be selected to destroy the entire facility or smaller ADM may be selected, consistent with separation distance, to destroy critical portions of the installation. In either event, the primary nuclear effect is generally blast overpressure.

b. The area target technique involves the selection of a yield which insures moderate to severe damage for the entire installation area. Residual radiation in the surrounding area may be reduced by placing the ADM on a tall structure with little mass such as a smokestack.

c. With selective destruction techniques, the most important elements or areas of the plant are chosen for destruction. If the installation has its own powerplant and if substitute power is not readily available, destruction of the powerplant denies use of the entire facility. Other elements crucial to operations of specified target complexes would be the blast furnaces in a steel mill or the cracking plant in a petroleum refinery. However, before employing ADM, consideration should be given to the use of conventional demolitions against targets of this type.



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CHAPTER 7 TROOP AND INSTALLATION SAFETY

Section I. INTRODUCTION

7-1. General

The surface or subsurface detonation of an ADM not only produces a crater but usually is accompanied by the release of radioactivity, airblast, ground shock, missiles, dust, and thermal radiation. Employment of ADM includes an evaluation of these nuclear effects which may result in hazards to friendly troops and the civil population; contamination of water sources; or damage to installations of military, political, or humanitarian importance.

7-2. Contingency Effects Tables

The contingency nuclear effects tables in ap-

pendix II and FM 101-31-2 provide general guidance for estimating the range to which certain effects extend. For tactical surface bursts, these tables usually are sufficient. However, when in close proximity to friendly troops or populated areas, it is necessary for the ADM target analyst to determine the influence of a variety of nuclear phenomena. Moreover, some nuclear effects such as fallout and blast overpressures can be suppressed, if not eliminated, by appropriate subsurface detonation. Consequently, this chapter in conjunction with chapter 2 discusses in more detail the extent of specific effects.

Section II. RADIOACTIVITY

7-3. General

The radioactivity released by a surface or shallow subsurface nuclear detonation is significant; thus troop safety from nuclear radiation is an important consideration. Adequate protective shielding is difficult to acquire. Moreover, it is reasonable to assume that personnel in the combat zone may receive repeated radiation doses. The amount and frequency of doses received in past operations and the urgency of the tactical situation must be considered in determining the degree of friendly troop exposure.

7-4. External Radiation Hazard

The external radiation hazard from a surface or underground nuclear detonation consists of initial and residual radiation. The biological response of the human body, however, is essentially the same for both (FM 101-31-1).

a. Initial nuclear radiation often produces casualties among personnel protected from

blast and thermal effects and is of considerable significance in assessing the radiation hazard.

b. Exposure to gamma radiation from fallout is perhaps the most far-reaching type of residual radiation hazard.

c. The total dose of radiation absorbed by an individual includes both the initial and residual radiation doses received. Although partial recovery of the human body from nuclear radiation damage does occur with the passage of time, the biological effects from repeated doses received during a relatively short period of a few weeks are essentially cumulative.

d. In view of the regularity of exposure, the nonrecoverability in the first 30 days, and the slow overall recovery, the commander must also consider the consequences of using personnel previously exposed to significant but non-symptomatic doses. To assist the commander, friendly units are divided into three categories based on previous exposure history. FM 3-12

discusses techniques for classifying units. The categories are—

(1) *Radiation Status-1 (RS-1)*. Units in this category do not have a significant radiation exposure history.

(2) *Radiation Status-2 (RS-2)*. Units in this category have previously received onetime or accumulated doses that are significant but not dangerous.

(3) *Radiation Status-3 (RS-3)*. Units in this category have received sufficient onetime or accumulated doses to make all except insignificant future radiation exposure dangerous.

e. Military personnel operating in a nuclear environment may expect radiation exposure as a normal combat hazard. Table 7-1 relates a unit's current radiation status (based on total past cumulative dose) to numerical troop safety criteria for future operations. The table assumes that no body recovery from radiation injury occurs.

Note. Reclassification of units from a more serious radiation status category to a less serious one is done by the commander upon advice of the surgeon after ample observation of actual state of health of the exposed personnel has been made.

f. Delay in the onset of the effects from comparatively small doses of nuclear radiation may permit some personnel to remain effective long enough to influence a specific operation. Nevertheless, the delayed effects may considerably reduce future combat effectiveness.

★Table 7-1. Nuclear Radiation Degree of Risk Exposure Criteria

Status	Total past cumulative dose	Single exposure criteria
RS-1 unit	< 75 rad	Negligible risk ≤ 5 rad
		Moderate risk > 5 ≤ 20 rad
		Emergency risk > 20 ≤ 50 rad
RS-2 unit	75 to 150 rad	All further exposure considered Moderate or Emergency risk
		Moderate risk ≤ 5 rad
		Emergency risk > 5 ≤ 20 rad
RS-3 unit	> 150 rad	All further exposure considered Emergency risk

★7-5. Shielding and Attenuation

The amount of radiation received at any point is dependent on the distance from the point of a nuclear detonation and the nature of the surrounding material. All matter will absorb some nuclear radiation, and thus provide some shielding. Shielding against gamma rays is provided mainly by mass; an equal weight of one material is about as effective as any other, so the denser the material, the better it serves as a gamma shield. This is why lead usually is used to protect against gamma rays. Neutrons, on the other hand, are captured much more readily by some elements than by others, and the value of the shielding depends almost entirely on what it is made of. Lead is a very poor shield against neutrons. One of the better elements for shielding against neutrons is hydrogen, which is concentrated in water and organic matter. To shield against both neutrons and gamma rays, such materials as concrete and damp earth are a good compromise.

7-6. Military Significance of the Initial Nuclear Radiation Exposure Hazard

a. A knowledge of the variation of initial radiation intensities with the range from a nuclear detonation is necessary in order to assess the immediate external radiation. At the present time, initial radiation data are available for air and surface detonations only (app II and FM 101-31-2). The shielding of the initial radiation by dust and debris produced by a subsurface explosion, as well as absorption by the surrounding media, will cause a considerable reduction in the exposure dose at any given distance. The extent of this reduction, however, cannot be quantitatively estimated at this time.

b. In the downwind direction from a nuclear detonation, both initial radiation and fallout contribute to the total dose of nuclear radiation.

7-7. Factors Influencing Fallout Distribution

The distribution and intensity of gamma radiation resulting from radioactive fallout is primarily dependent on the following factors:

a. The kinds and quantities of radioactive materials produced by the explosion.

b. The fraction of the radioactive materials produced that escapes to the atmosphere.

c. The dimensions of the main cloud.

d. The wind speed and direction up to maximum cloud height.

e. The dimensions of the base surge cloud. The base surge is a physical phenomenon of nuclear detonations occurring beneath the surface of either ground or water (a surface burst does not create a base surge). It is formed in essentially the same manner for either underground or underwater bursts and consists of a low level radioactive cloud surrounding ground zero. The significance of the base surge with regard to radiation varies somewhat for the two media. In both cases, the base surge cloud radius is considered in troop safety because there could be a very high radiation dose rate within its confines. For the underwater burst, the base surge is transient, and its contribution to residual radiation is expected to be minor. The underground burst base surge, on the other hand, may contribute significantly to residual radiation. (See TM 23-200 for further details.)

★7-8. Radioactivity Escape

a. The radioactivity generated in cratering explosions is distributed in three ways—

(1) A large fraction of the radioactivity produced is trapped by particles of debris and *ejecta* which fall back into the crater or on the lip and end up buried in the rubble.

(2) A smaller fraction of the radioactivity produced escapes from the crater, is deposited on large dust particles, and becomes a part of the dust cloud. These large radioactive particles are deposited as local fallout.

(3) A much smaller fraction of the radioactivity produced escapes from the crater, is deposited on minute dust particles or remains a gas, and may be carried for great distances and contribute to worldwide fallout.

b. The relative amount of the activity which escapes as local fallout depends on how deep the ADM is buried compared to the depth of the resulting crater. For cratering detonations at optimum depth of burst, it has been estimated that less than 15 percent of the total radioactive debris is released to the atmosphere. Of this small amount about 80 percent is dis-

★Table 7-2. Downwind Distances of Zones I, I-A, and II (kilometers)

YIELD (KT)	Surface burst DOB = 0			Subsurface burst DOB = 15W ^{0.3} m			Optimum burial DOB = 49W ^{0.3} m		
	ZONE I	ZONE I-A	ZONE II	ZONE I	ZONE I-A	ZONE II	ZONE I	ZONE I-A	ZONE II
SIERRA/0.01	.48	.79	1.1	.56	.77	.97	≤.4	≤.4	≤.4
TANGO/0.03	.71	1.3	1.8	.83	1.2	1.5	≤.4	≤.4	≤.4
UNIFORM/0.05	.94	1.7	2.5	1.1	1.7	2.2	≤.4	≤.4	≤.4
VICTOR/0.1	1.5	2.7	3.8	1.7	2.5	3.3	≤.4	0.40	0.57
WHISKEY/0.30	3.6	5.4	7.2	4.0	5.1	6.2	0.54	0.71	1.1
ALPHA/0.5	4.4	6.6	8.8	4.8	5.7	7.6	0.66	0.99	1.3
BRAVO/1.0	5.7	8.6	11.4	6.2	7.9	9.5	0.86	1.3	1.7
DELTA/5.0	12.0	18.0	24.0	12.7	16.2	19.7	1.8	2.7	3.6
ECHO/10.0	15.0	22.5	30.0	15.9	20.3	24.6	2.3	3.5	4.5
GOLF/50.0	30.0	45.0	60.0	31.5	40.1	48.6	4.5	6.8	9.0
HOTEL/100.0	39.0	58.5	78.0	40.6	51.9	63.1	5.9	8.9	11.7

Notes. An effective wind speed of 15 knots (27 Km/hr) is assumed. Downwind distances are based on fallout prediction using TM 3-210.

ZONE I: A zone within which there will be areas where exposed, unprotected personnel may receive doses greater than 50 rad (the emergency risk dose) in relatively short periods of time (less than 1 hour after arrival of fallout).

ZONE I-A: A zone within which there will be areas where exposed unprotected personnel may receive doses greater than 50 rad (the emergency risk dose) in relatively short periods of time (less than 4 hours after actual arrival of fallout).

ZONE II: A zone within which the total dose to exposed, unprotected personnel is not expected to exceed 50 rad when remaining in the area for not more than 4 hours after the actual arrival of fallout.

tributed in the main cloud and 20 percent in the base surge. Until data are available for shallow depths of burst, this distribution of radioactive debris is also assumed for shallow burial.

★7-9. Fallout Prediction Procedures

Numerous fallout prediction procedures have been developed. Most of them are for specific applications. The procedures presented by TM 3-210, however, are recommended for use in tactical situations to determine those areas

within which exposed, unprotected personnel may receive a militarily significant total dose of nuclear radiation in the first several hours after actual arrival of fallout. Table 7-2, based on TM 3-210, illustrates typical downwind distances of Zones I, IA, and II for surface and subsurface bursts. Note that there is an initial increase in the downwind distance of Zone I as depth of burst is increased from surface to shallow, and that there is a significant decrease for all zones as the depth of burst is increased to optimum.

Section III. BLAST

7-10. General

a. The direct effects of blast are an important troop safety consideration.

(1) High overpressures estimated at 45 to 55 psi for nuclear explosions cause immediate deaths while lower overpressures on the order of 20 to 35 psi may cause severe internal injuries especially to the lungs or abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from overpressures as low as 5 psi. Personnel in field fortifications may become casualties at lower incident blast overpressures built up by multiple reflections within small inclosures to casualty-producing levels.

(2) Translation, the process by which personnel and material objects are picked up and thrown, is the basis for prediction of blast casualties to personnel in the open.

b. Secondary effects of blast also produce personnel casualties.

(1) Flying debris, stones, and sand are converted to missiles by the blast wave, thereby causing casualties to unprotected personnel. Hot, dust-laden gases may cause burns. Airborne dust may cause irritation and possible suffocation as well as limit visibility and movement within and adjacent to the target area.

(2) Buildings or fortifications may collapse on personnel.

7-11. Degree of Risk and Damage Criteria

a. Tactical Employment.

(1) In tactical operations involving the use of atomic demolition munitions, the primary area of concern is the close-in region in

which structures of military significance and personnel are subjected to damaging overpressure levels from airblast. The following criteria have been established for determining troop safety distances for warned, protected personnel (foxhole protection):

Degree of Risk	Blast Overpressure—psi
Negligible	4.0
Emergency	10.0

(2) The above blast criteria, however, do not preclude all blast injuries to protected personnel. Personnel in tanks subjected to 10 psi overpressure will probably receive no significant injuries. Personnel in foxholes, however, may become indirect blast casualties as a result of foxhole collapse. An overpressure of 4 psi (negligible risk) does not cause sufficient damage to either tanks or foxholes to produce either direct or indirect casualties.

(3) Damage criteria for structures and field fortifications of tactical significance are given in appendix III.

★b. *Preclusion of Damage Operations.* When it is desired to preclude damage to nearby structures, potential airblast damage from ADM must be evaluated. Normally, 1 psi overpressure is used as the criterion for preclusion of light damage due to air blast.

★7-12. Prediction of Close-In Airblast for Cratering Detonations

a. Close-in airblast overpressures resulting from subsurface detonations are considerably less than those generated by an air or surface burst at the same ground zero. Figure 7-1 is a family of curves representing peak air over-



Figure 7-1. Air overpressures at the surface from surface/subsurface bursts, in a dry soil medium, normalized to 1 kiloton.

pressures on the surface as a function of depth of burst and surface range for a yield of 1 kt in a dry soil medium. In a rock medium, air blast is reduced to a much greater extent. Distances in figure 7-1 may be used for cratering detonations in a rock medium at depths greater than $50 W^{0.3}$ feet ($15 W^{0.3}$ meters) if they are reduced by 50 percent. The depth of burst and the range to which a given peak overpressure extends are directly proportional to the cube root of the yield:

$$\frac{r}{R} = \frac{dob}{DOB} = \frac{W_1^{1/3}}{W_2^{1/3}}$$

Where r is the radius to which a given overpressure extends for yield W_1 (1 kiloton); R is the corresponding radius to which the given overpressure extends for yield W_2 kiloton; dob is the depth of burst for yield W_1 (1 kiloton) and DOB is the corresponding depth of burst for yield W_2 kiloton, the actual depth of burst.

b. The following example illustrates the recommended procedure for predicting close-in airblase overpressure levels resulting from cratering detonations:

Given: It is planned to use a 10-kiloton device detonated at a depth of 100 feet as a part of a preplanned barrier operation to deny enemy access through a narrow defile.

Find: The distance to which 4 psi overpressure will extend.

Solution: Applying the above scaling law, the dob for 1 kiloton is determined as follows:

$$\frac{dob}{DOB} = \frac{W_1^{1/3} \text{ kt}}{W_2^{1/3} \text{ kt}}; \frac{dob}{100 \text{ ft}} = \frac{1}{2.15}$$

$$dob = \frac{100(1)}{2.15} = 46.5 \text{ ft}$$

Enter figure 7-1 with $dob = 46.5 \text{ ft}$ and at the intercept of the 4 psi curve read an $r = 870$ feet or 265 meters. Solve for R , the radius of 4 psi overpressure from the 10-kt detonation:

$$\frac{r}{R} = \frac{W_1^{1/3}}{W_2^{1/3}}; \frac{265\text{m}}{R} = \frac{1}{2.15}$$

$$R = 265\text{m} \times 2.15 = 570\text{m}$$

Answer: 570 meters.

Section IV. MISSILE HAZARD

7-13. General

One of the hazards associated with nuclear cratering is the ejection of large particles of debris which travel along ballistic paths as missiles and are deposited at considerable distances from ground zero. These missiles

are potential casualty-producing agents and can also cause severe damage to structures and equipment. Figure 7-2 shows the venting of the 100-kt detonation. A number of missiles, each trailing the dust plume which marks the trajectory, are visible in the figure.

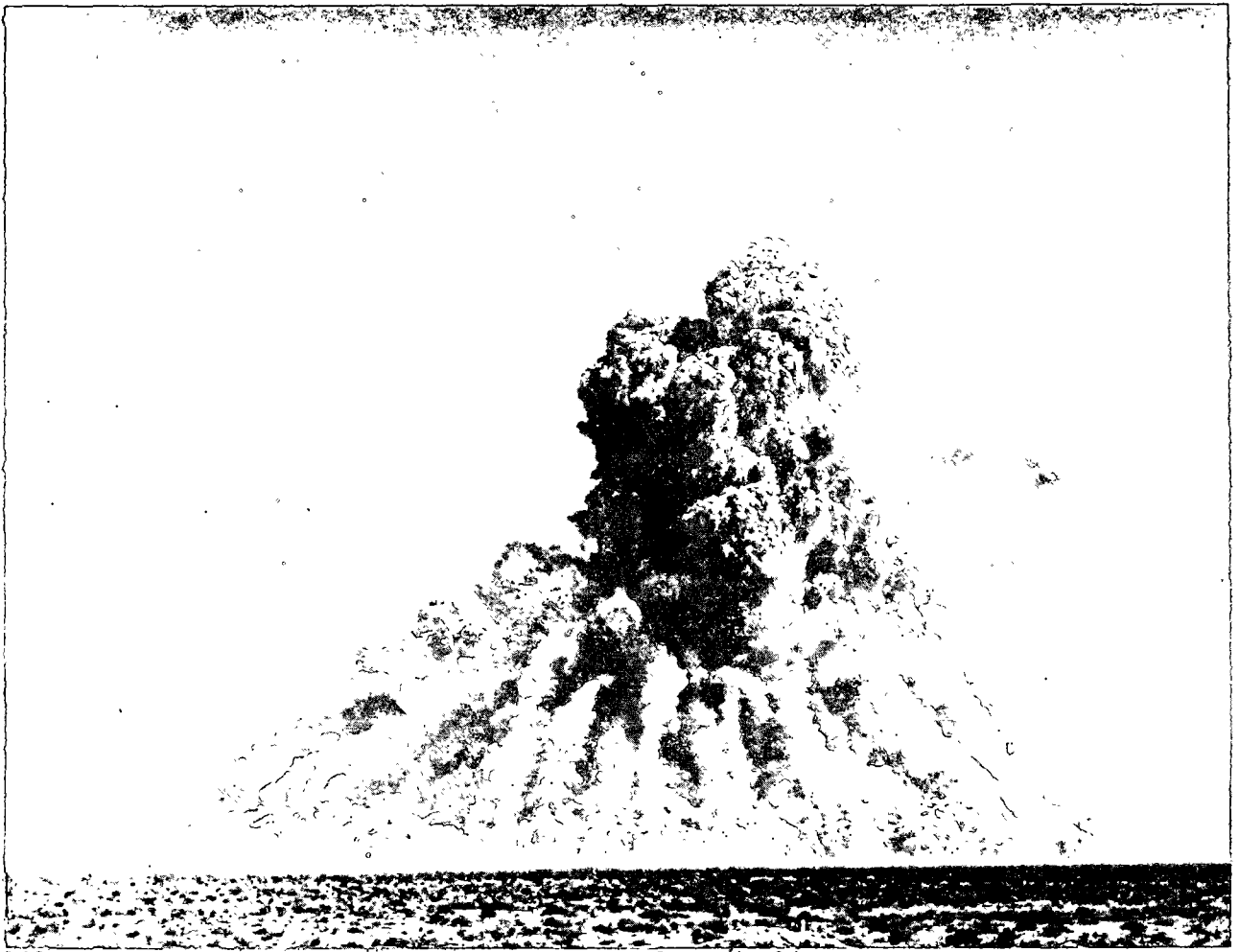


Figure 7-2. Venting of the 100-kt detonation showing missiles.

7-14. Description of Missiles Ejected by Cratering Detonations

a. General.

- (1) The *ejecta* resulting from a nuclear cratering detonation is distributed randomly over a large area surrounding the crater in three zones from the crater edge outward as follows: the crater lip; the area in which mounds or rays of *ejecta* may be found; and the region of dust and missiles. A typical *ejecta* pattern is shown in figure 7-3.
- (2) The distance to the outer edge of the crater lip is considered to be the average distance from ground zero at which there is no significant difference in preshot and postshot elevation. This distance (R_L) varies between 1.5 and 2.5 times the apparent crater radius depending on the depth of burst of the ADM. Between the crater lip and the region of dust and missiles, and overlap-

ping both areas, is a region in which the *ejecta* may be distributed in a pattern characterized by a concentration of material in radially or tangentially oriented longitudinal mounds. The radially oriented mounds or rays usually begin in the lip and may be continuous from the lip to their outer extremity. In rock or soil containing a high percentage of boulders, the rays may consist only of elongate concentrations of rocks rather than mounds of material. As used in this section, the term *missiles* refers to boulders, rock fragments, or masses of solid earth that travel along ballistic paths from ejection to impact.

- (3) The missile hazard is not considered a limiting effect for ADM employment. However, personnel within the area should be cautioned and equipment, which may be damaged should be moved or protected.

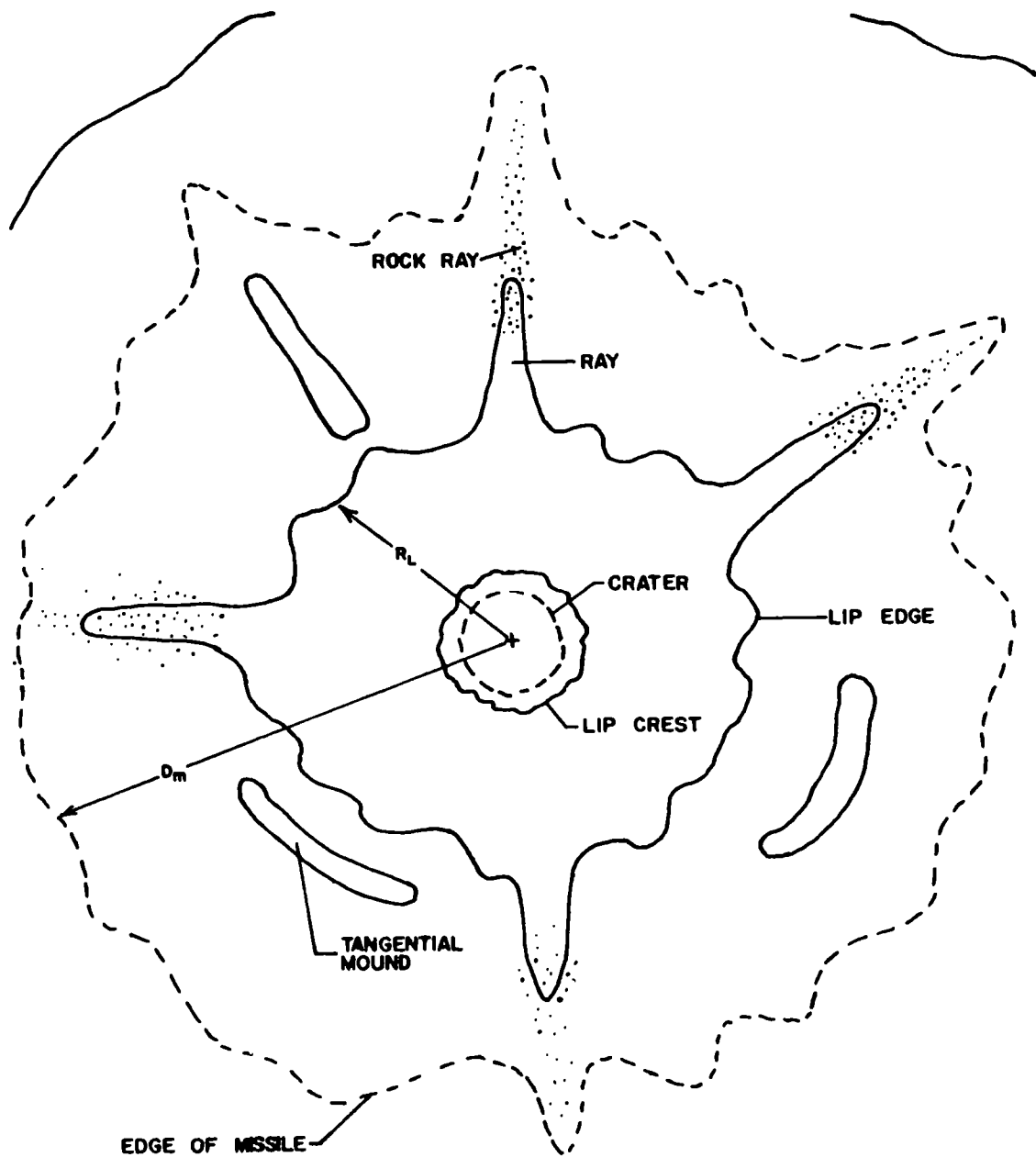


Figure 7-3. Typical ejecta pattern.

b. Missile Sizes and Weights.

(1) Missiles vary in weight from less than a pound to several tons. In general, at the more distant ranges, the largest and smallest sizes are not usually found. At the intermediate ranges all sizes appear to be present except the largest missiles which weigh several tons and are rarely found beyond the edge of the lip (fig. 2-1).

(2) The Armed Services Safety Board has indicated that a 1-pound missile is capable of producing a fatal injury; and upon this criterion, the minimum weight missile used in compiling the data for this section is based.

c. Missile Impact.

(1) The impact of a missile from a cratering detonation on a surface other than rock usually creates an elongated, shallow crater with a lip thrust up on the side away from the explosion. The missiles from a detonation in soil usually disintegrate upon impact.

(2) Upon impact, rock missiles either shatter—sending a shower of fragments over the surrounding area—or rebound. Because the larger rock missiles are tumbling in flight, the rebound pattern is usually erratic; one missile, therefore, is capable of causing multiple damage.

d. Missile Velocities. The estimated initial velocities of missiles resulting from nuclear cratering explosions in dry soil range between 400 and 1200 feet per second. The initial velocities of missiles from cratering detonations in hard noncarbonate rock range between 100 and 400 feet per second.

7-15. Maximum Missile Range

a. Figure 7-4 gives curves which can be used to estimate the maximum ranges of missiles from a cratering detonation. It should be noted that there is a wide variation in the distance to the outermost missile at various orientations around a crater. The curves in figure 7-4 represent an upper limit of missile ranges for the materials indicated.

b. It is recommended that the dry soil curve in figure 7-4 be used for nuclear detonations in

all dry soils except those having a high percentage of boulders. The hard rock curve should be used for rock media, for dry soils having a high percentage of rocks or boulders, and for wet soils. For nuclear detonations in a gas-forming rock such as limestone, the maximum missile ranges determined from the hard rock curve should be increased by 20 percent to account for the anticipated increase in range resulting from greater gas acceleration.

★*c.* The following example illustrates the recommended procedure for estimating the maximum range of missiles from cratering detonations.

Given: A VICTOR/0.1 ADM is to be detonated at a depth of burst of 60 feet in hard rock.

Find: The maximum missile range (D_m) for the detonation.

Solution:

$$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

$$\text{Substituting: } \frac{60}{DOB_2} = \frac{(0.1)^{0.3}}{(1)^{0.3}}$$

$$DOB_2 = \frac{60(1)^{0.3}}{(0.1)^{0.3}}$$

$$= \frac{60}{0.5}$$

$$= 120 \text{ ft for a 1 kt yield}$$

Using this DOB and the hard rock curve in figure 7-4, d_m (for 1 kt) = 8,000 ft.

$$\frac{d_m}{D_m} = \frac{W_1^{0.3}}{W_2^{0.3}}$$

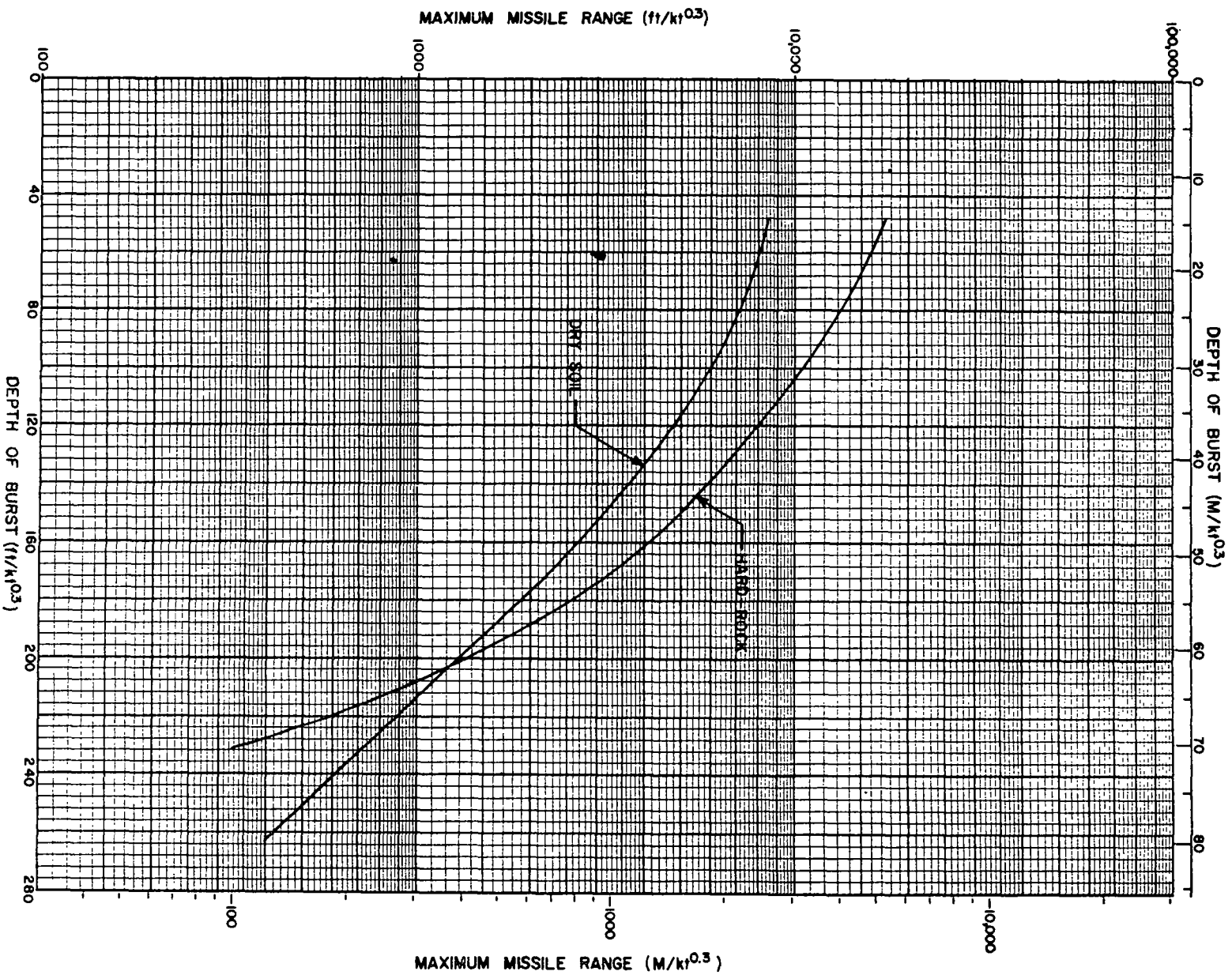
$$\text{Substituting: } \frac{8000}{D_m} = \frac{(1)^{0.3}}{(0.1)^{0.3}}$$

$$D_m = \frac{8000(0.1)^{0.3}}{(1)^{0.3}}$$

$$= \frac{8000(0.5)}{1}$$

$$= 4000 \text{ ft}$$

Answer: D_m = 4,000 feet or 1,220 meters.



★Figure 7-4. Maximum missile ranges for subsurface bursts in dry soil and hard rock, normalized to 1 kiloton.

Section V. THERMAL RADIATION

7-16. General

In subsurface bursts, if the fireball does not penetrate through the ground surface, practically all the thermal radiation released by the detonation is used in the vaporization and melting of the medium surrounding the device. Even for shallow depths of burst in which the fireball penetrates the ground surface, the intensity of thermal radiation received at a given distance from the detonation is considerably less than for the surface burst (para 2-10).

★7-17. Intensities From Subsurface Bursts

The variation of thermal radiation intensities with distance from the detonation has been documented for airbursts and surface bursts. No data are available, however, which can be used to quantitatively estimate the thermal radiation intensities at varying distances from

subsurface bursts. Below scaled depths of approximately $15 W^{0.3}$ feet ($5 W^{0.3}$ meters), the radius of the base surge cloud from a detonation is greater than the distances to which militarily significant levels of thermal radiation are transmitted. For the purpose of assessing the thermal radiation hazard from subsurface bursts, therefore, it is assumed that—

a. For scaled depths of bursts less than $15 W^{0.3}$ feet, the thermal effects predicted for a surface burst may be used to estimate the intensities to be expected from a subsurface burst.

b. For scaled depths of bursts of $15 W^{0.3}$ feet or deeper, there is no militarily significant thermal radiation at distances beyond the area engulfed by the base surge cloud. For scaled depths of burst of $50 W^{0.3}$ feet or deeper, the fireball is contained underground and there are no thermal radiation effects to consider.

★Section VI. GROUND SHOCK

7-18. General

Cratering with ADM results in the transmission of energy into the ground as well as into the air. Most of the energy transferred to the ground is in the vicinity of ground zero. A small percentage of the energy results in ground shock which is measurable at considerable distances from the point of detonation. This ground shock may be of sufficient magnitude to cause significant damage to structures in the vicinity of the detonation. Thus, ground shock could be the primary damage consideration when burial reduces other nuclear effects.

7-19. Factors Affecting Damage by Ground Shock

a. *Geology.* Transmission of shock waves between the shot point and structures of interest is dependent on the geology of the area. The local and intervening geology have profound effects on the amount of ground shock. For example, the ground shock in granite, basalt, or other hard rocks may be as much as ten times greater than in alluvium. Most of the ground shock measurements which have been made during tests are for fully-contained underground nuclear explosions. Therefore, ground

shock predictions are currently based on the data for fully-contained underground nuclear detonations.

b. *Type and Location of Structures.*

(1) *Underground structures.* Within the regions of the rupture and plastic zones of a crater, damage to underground structures due to ground shock will range from complete collapse to damage sufficient to seriously impair the operational capability of the structure. The plastic zone, therefore, can be established as the limit beyond which no militarily significant ground shock damage to underground structures will occur.

(2) *Surface structures.* Evaluation of ground shock damage to surface structures must include the vulnerability of structures ranging from those specifically designed to resist the force of ground shock, to normal residential-type buildings. The criteria for precluding ground shock damage to structures are based on residential-type buildings so that damage to stronger structures will also be precluded.

c. *Damage Criteria.* Two sets of criteria, acceleration and surface velocity, are normally

used to evaluate ground shock damage. Based on high explosive tests, a ground acceleration of 1.0g will cause cracking and falling of plaster. An equivalent amount of damage occurs with a peak surface velocity of about 25 cm/sec. Of the two criteria, velocity appears to more closely correlate with damage from a nuclear detonation. Therefore, a peak surface velocity of 25 cm/sec is used as the criterion to evaluate the extent of light damage to surface structures due to ground shock from an underground nuclear detonation.

7-20. Prediction of Ground Shock

Table 7-3 represents the surface range from ground zero to a peak surface velocity of 25 cm/sec for the hypothetical ADM family in hard rock and alluvium cratering detonations. These ranges do not apply to the region in which the media has been subjected to fracturing or plastic deformation (plastic zone) as a result of a cratering detonation. In linear cratering from multiple charge row detonations, assume a single yield equal to the total yield to be detonated simultaneously, with the detonation occurring at the center of the row of charges.

Table 7-3. Ground Shock Range (meters) for Underground Nuclear Detonations
Range to peak surface ground shock velocity of 25 cm/sec

Model/Yield (kt)	Dry Soil	Hard Rock
Sierra/0.01	20	65
Tango/0.03	30	105
Uniform/0.05	40	130
Victor/0.10	50	180
Whiskey/0.30	90	285
Alpha/0.5	110	360
Bravo/1	150	500
Delta/5	300	1000
Echo/10	430	1370
Golf/50	850	2750
Hotel/100	1160	3880

7-21. Illustrative Example

Given: A BRAVO/1 kiloton ADM is to be detonated at optimum depth in rock.

Find: The distance at which residential-type structures will be subjected to light damage (peak surface velocity of 25 cm/sec).

Solution: Enter Table 7-3 with 1 kt and read over to the column for rock. Read a distance of 500 meters.

Answer: 500 meters.



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★ **APPENDIX I****REFERENCES****AI-1. Army Regulations**

50-1	U.S. Army Nuclear Weapons Surety Program
50-2	Nuclear Weapon Accident and Incident Control
50-3	Personnel Security Standards for Nuclear Capable Organizations and Activities
55-203	Movement of Nuclear Weapons Components and Nuclear Weapons Material
95-55	Nuclear Weapon Jettison
190-60	Physical Security Standards for Nuclear Weapons
380-5	Safeguarding Defense Information
380-20	Restricted Areas
380-25	Visitors
380-55	Safeguarding Defense Information in Movement of Persons and Things
380-150	Security of Restricted Data
380-157	Policy and Procedure for Regulating Access to Critical Atomic Weapons Stockpile and Production Information
385-25	Studies and Reviews, Nuclear Weapon System Operational Surety Program
385-30	Safety Color Code Markings and Signs
385-40	Accident Reporting and Records
385-65	Identification of Inert Ammunition and Ammunition Components
604-5	Clearance of Personnel for Access to Classified Defense Information and Materiel
611-15	Selection and Retention Criteria for Personnel in Nuclear Reactor or Nuclear Weapons Positions
611-103	Officer Qualifications and Classification
611-201	Enlisted Military Occupational Specialties

AI-2. Field Manuals

3-8	Chemical Reference Handbook
3-10	Employment of Chemical and Biological Agents
(S) 3-10A	Employment of Biological Agents (U)
(C) 3-10B	Employment of Chemical Agents (U)
3-12	Operational Aspects of Radiological Defense
3-15	Nuclear Accident Contamination Control
5-1	Engineer Troop Organizations and Operations
5-15	Field Fortifications
5-25	Explosives and Demolitions
5-29	Passage of Mass Obstacles
5-30	Engineer Intelligence
5-31	Boobytraps
5-33	Engineer Cellular Teams
5-34	Engineer Field Data

5-35	Engineers' Reference and Logistical Data
5-36	Route Reconnaissance and Classification
5-135	Engineer Battalion, Armored, Infantry, and Infantry (Mechanized) Divisions
5-136	Engineer Battalions, Airborne and Airmobile Divisions
5-142	Nondivisional Engineer Combat Units
6-20-1	Field Artillery Tactics
6-20-2	Field Artillery Techniques
9-6	Ammunition Service in the Theater of Operations
19-3	Military Police Support in the Communications Zone
19-25	Military Police Traffic Control
19-30	Physical Security
20-32	Landmine Warfare
21-30	Military Symbols
21-40	Chemical, Biological, and Nuclear Defense
24-18	Field Radio Techniques
24-20	Field Wire and Field Cable Techniques
30-5	Combat Intelligence
30-10	Terrain Intelligence
31-10	Barriers and Denial Operations
61-100	The Division
100-5	Field Service Regulations—Operations
101-5	Staff Officers' Field Manual; Staff Organization and Procedure
101-31-1	Staff Officers' Field Manual; Nuclear Weapons Employment
(S) 101-31-2	Staff Officers' Field Manual; Nuclear Weapons Employment (U)
101-31-3	Staff Officers' Field Manual; Nuclear Weapons Employment

AI-3. Technical Manuals

3-210	Fallout Prediction
5-545	Geology and its Military Applications
(S) 9-1100-205-12	Operator and Organizational Maintenance Manual; Atomic Demolition Charge XM129E1, XM129E2, XM159E1, XM159E2 and Training Atomic Demolition Charge XM130E1 (U)
9-1100-205-20P	Organizational Maintenance Repair Parts and Special Tools List; Charge, Atomic Demolition; XM129E1, XM129E2, XM159E1, XM159E2, and Charge, Atomic Demolition, Training, XM130E1
(S) 9-1100-226-12	Operator and Organizational Maintenance Manual (Prefire Procedures for Employment) : Atomic Demolition Charges XM127, XM127E1, XM160, XM160E1, XM166, XM167, XM172, XM173, XM174, XM175, and Coder-Transmitters XM3 and XM4 (U)
(S) 9-1100-226-20P	Organizational Maintenance Repair Parts and Special Tool Lists (Illustrated Parts Breakdown) for Charge, Atomic Demolition: XM127, XM127E1, XM160, XM160E1, XM166, XM167, XM172, XM173, XM174, XM175 and Coder-Transmitters XM3 and XM4 (U)
(C) 23-200	Capabilities of Nuclear Weapons (U)
38-750	Army Equipment Record Procedures
(S) 39-0-1A	Numerical Index to Joint Atomic Weapons Publications (Army Supplement) (U)
(C) 55-1100-205-12-Series	Air Transportability Procedures: Atomic Demolition Charge XM129, XM129E1 or XM159, XM159E1 in Army Aircraft (U)

55-1100-226-
12-Series

Air Transportability Procedures: Atomic Demolition Charge XM167, XM172, XM175 and XM160E1 and Remote Command Equipment in Army Aircraft.

★A1-4. Other DA Publications

DA Pam 39-3	The Effects of Nuclear Weapons.
ASubjScd 5-18	Atomic Demolition Munitions.
TB 9-1100-807-15	Loading, Tiedown and Unloading of Nuclear Weapon Shipping and Storage Containers on Tactical Vehicles.
TB 9-2300-280-30	Installation of Universal Tie-down Anchors.
TB IG-5	Inspector General Technical Proficiency Inspection.
DA Form 2706	Assignment Certificate.
DA Form 3179	Nuclear Duty Position Evaluation Request.
DA Form 3180	Nuclear Duty Position Screening Evaluation.
DA Form 3181	Nuclear Duty Position Medical Notification.



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APPENDIX II

HYPOTHETICAL ADM EFFECTS TABLES

A2-1. General

a. This appendix provides an unclassified reference for instruction in the employment of atomic demolition munitions. The data contained herein are based on unclassified sources; consequently, the limitations of this manual must be recognized. This appendix may be used

in basic instruction in units and in service schools where utilization of classified reference material is not desirable.

b. Design characteristics of the hypothetical family of ADM listed in table 3-1 are repeated below to facilitate their use in conjunction with other tables in this appendix.

Model-yield (kt)	Canister length		Emplacement hole diameter		Transportation weight (pounds)
	Feet	Meters	Inches	Meters	
SIERRA0.01	3	0.91	15	0.38	100
TANGO0.03	3	0.91	15	0.38	100
UNIFORM0.05	3	0.91	15	0.38	100
VICTOR0.10	3	0.91	15	0.38	100
WHISKEY0.30	3	0.91	15	0.38	100
ALFA0.50	5	1.52	30	0.76	500
BRAVO1	5	1.52	30	0.76	500
DELTA5	5	1.52	30	0.76	500
ECHO10	10	3.05	36	0.91	1500
GOLF50	10	3.05	36	0.91	1500
HOTEL100	10	3.05	36	0.91	1500

c. The following tables are included in this appendix:

(1) Severe moderate blast damage for surface bursts.

(2) Subsurface airblast damage reduction distances.

(3) Crater dimensions for dry soil or soft rock.

(4) Fire areas for surface burst.

(5) Thermal criteria for fuel ignition.

(6) Tree blowdown for surface burst.

(7) Extent of blast overpressures for surface and subsurface bursts.

(8) Troop safety distances for surface burst.

(9) Light aircraft in flight safety radii for surface burst.

★Table II-1. Severe/Moderate Airblast Damage Radii for Surface Bursts (meters)

Material classification		Sierra 0.01	Tango 0.03	Uniform 0.05	Victor 0.10	Whiskey 0.30	Alfa 0.50	Bravo 1	Delta 5	Echo 10	Golf 50	Hotel 100
Wheeled Military Vehicles Railroad Cars	Mod	70	80	95	110	160	185	230	550	700	1450	1900
	Sev	45	55	75	90	100	125	175	325	450	900	1450
Tanks and Artillery Railroad Locomotives	Mod	45	55	65	80	95	115	160	300	400	825	1030
	Sev	30	45	55	65	70	75	115	195	300	600	750
Communications Equip	Sev	85	95	120	160	195	230	300	625	885	1835	2400
Supply Dumps	Sev	20	25	30	35	40	60	80	155	230	470	650
Truss & Float Bridges	Mod	60	70	90	105	130	150	190	420	545	1100	1450
	Sev	40	50	60	75	90	105	175	340	390	830	1250
Field Fortifications	Mod	35	45	55	70	80	85	125	210	260	470	790
Earth Covered Surface Shelters	Sev	35	45	60	65	75	80	100	200	245	440	605
Monumental-Type Multistory Wall-Bearing Bldgs.	Mod	150	170	210	250	290	350	575	840	1100	1800	1975
Multistory, Wall-Bearing Bldgs (Apt House Type)	Sev	100	130	165	200	235	275	400	680	825	1400	1580
Multistory, Reinforced Bldgs (small window area) Multistory, Steel Frame Office Bldgs. Blast Resistant Reinforced Concrete Bldgs. Light Steel Frame Industrial Bldgs.	Mod	65	80	100	130	165	200	350	450	650	1250	1450
	Sev	50	55	65	85	100	125	160	245	525	975	1200
Oil Storage Tanks	Mod	225	250	285	365	425	505	640	1150	1575	2865	3150
Parked Combat Aircraft	Sev	150	165	205	255	285	340	450	800	1035	1870	1950
Wood Frame Bldgs.	Mod	210	240	295	335	450	500	800	1205	1550	2850	3450
	Sev	140	170	195	250	300	350	690	930	1190	2215	2790

Table II-2. Airblast Damage Reduction Distances, Subsurface Burst (meters).

DOB (meters)	Sierra 0.01	Tango 0.03	Uniform 0.05	Victor 0.10	Whiskey 0.30	Alfa 0.50	Bravo 1	Delta 5	Echo 10	Golf 50	Hotel 100
1	2	3	4	6	7	8	10	18	33	55	85
2	5	6	8	10	11	12	15	23	42	63	98
3	10	16	19	22	23	25	30	54	78	107	145
4	17	19	22	23	25	30	40	79	110	165	215
5	27	30	35	40	44	48	60	115	160	220	330
6	35	38	42	50	53	61	80	155	210	345	425
7	-----	-----	-----	60	65	80	100	190	305	405	515
8	-----	-----	-----	-----	85	105	130	220	415	500	595
9	-----	-----	-----	-----	-----	145	165	275	510	585	635
10	-----	-----	-----	-----	-----	-----	205	335	605	675	700
15	-----	-----	-----	-----	-----	-----	-----	410	710	785	820
25	-----	-----	-----	-----	-----	-----	-----	-----	800	890	950
40	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1125

Note. To determine the airblast damage radii to various material targets for subsurface detonations, the distances given in this table must be subtracted from the airblast damage radii associated with surface bursts as shown in table II-1. Should the result be a negative number consider that the damage radii is zero.

★Table II-3. Crater Dimensions for Dry Soil or Soft Rock*

Model/Yield (kt)	Approximate crater dimensions (meters)								
	Surface			15W ^{0.3} meters (shallow)			49W ^{0.3} meters (optimum)		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
SIERRA/0.01 -----	0	9	2	4	21	6	12	27	7
TANGO/0.03 -----	0	12	2	5	30	8	17	37	10
UNIFORM/0.05 -----	0	15	3	6	34	9	21	44	12
VICTOR/0.10 -----	0	18	4	7	43	11	24	53	14
WHISKEY/0.30 -----	0	27	5	10	60	16	34	75	20
ALFA/0.5 -----	0	32	6	12	69	19	40	87	23
BRAVO/1 -----	0	40	8	15	85	23	49	107	28
DELTA/5 -----	0	68	14	24	139	37	79	173	45
ECHO/10 -----	0	86	17	30	169	46	97	213	56
GOLF/50 -----	0	147	30	48	274	74	159	347	91
HOTEL/100 -----	0	185	37	60	338	91	195	426	111

*For hard rock or concrete, use a 0.8 multiplication factor.

*Table II-4. Fire Areas for Surface Burst **

Yield kt	Expected radii for ignition of wildland fuels during fire season—meters							
	Dry climate (25 percent relative humidity)				Damp climate (75 percent relative humidity)			
	Class I	Class II	Class III	Class IV	Class I	Class II	Class III	Class IV
SIERRA/0.01-----	225	200	200	175	225	200	200	175
TANGO/0.03-----	250	250	250	225	250	250	250	225
UNIFORM/0.05-----	300	300	275	250	300	300	275	250
VICTOR/0.10-----	375	375	325	350	375	375	325	350
WHISKEY/0.30-----	400	400	350	350	400	400	350	350
ALFA/0.5-----	500	500	400	400	500	500	400	400
BRAVO/1-----	700	600	500	500	600	600	500	400
DELTA/5-----	1,200	1,100	1,000	800	1,100	1,100	900	700
ECHO/10-----	1,500	1,400	1,300	1,100	1,400	1,400	1,200	900
GOLF/50-----	2,800	2,600	2,300	2,000	2,600	2,600	2,200	1,600
HOTEL/100-----	3,500	3,200	3,000	2,500	3,200	3,200	2,800	2,100

* For description of fuel classes, see table II-5.

Table II-5. Thermal Criteria for Fuel Ignition

Forest fuels		Ignition energy (CAL/CM)			
		Relative humidity 25 percent		Relative humidity 75 percent	
Class	Description	1 kt	100 kt	1 kt	100 kt
I	Broadleaf and coniferous litter mixture of fine grass, broken leaves and duff, and thin translucent broad leaf leaves.	2	4	3	6
II	Hardwood and soft wood punk in various stages of decay.	3	5	3	6
III	Cured or dead grass.	4	7	4	7
IV	Conifer needles and thick nearly opaque broadleaf leaves.	5	9	8	14

Table II-6. Tree Blowdown for Surface Burst *

(All distances in meters)

Yield KT	Obstacles to movement							Casualties to exposed personnel		
	Foot and wheeled vehicle movement				Tracked vehicle movement			Type I	Types II, IVd(b)	Types III, IVf(a)
	Type I	Type II	Type III	Type IV	Type I	Types II, IVd(b)	Types III, IVf(a)			
SIERRA/0.01-----	50	75	75	200	50	75	75	50	75	75
TANGO/0.03-----	75	100	100	225	75	100	100	75	100	100
UNIFORM/0.5-----	100	125	125	250	100	125	125	100	125	125
VICTOR/0.10-----	125	135	135	275	125	135	135	125	135	135
WHISKEY/0.30-----	135	150	150	360	135	150	150	135	150	150
ALFA/0.5-----	150	200	200	350	150	200	200	150	200	200
BRAVO/1-----	200	300	300	500	200	300	300	200	300	300
DELTA/5-----	400	600	600	1,000	400	600	600	400	600	600
ECHO/10-----	600	800	900	1,350	600	800	900	600	800	900
GOLF/50-----	1,200	1,550	1,700	2,650	1,200	1,550	1,700	1,200	1,550	1,700
HOTEL/100-----	1,700	2,000	2,250	3,400	1,700	2,000	2,250	1,700	2,000	2,250

* These radii apply to contact surface bursts.

General description of forest stand types and criteria are—

- (1) **Type I.** Improved natural or planted conifer (evergreen) forests with uniform tree spacing height and diameter; occurs in Western Europe.
- (2) **Type II.** Naturally occurring unimproved conifer forests that have developed under unfavorable growing conditions with random tree spacing, height, and diameter; occurs in Western Europe and Southeast Asia.
- (3) **Type III.** Unimproved conifer forests that have developed under favorable growing conditions, characterized by random tree spacing and diameter, uneven crown canopy and

irregular clearings; occurs in Western Europe and Southeast Asia.

- (4) **Type IV.** Deciduous forests. Deciduous trees are trees that shed their leaves annually. The radius of tree blowdown depends on whether the trees have their leaves or have shed them. For this reason type IV forests are further subdivided as follows:

(a) **Type IVf.** Deciduous forest that is foliated (in leaf).

(b) **Type IVd.** Deciduous forest that is defoliated (leaves have been shed).

Table II-7. Extent of Blast Overpressures for Surface Burst

Yield kt	Radii (meters)			
	1 psi	4 psi	8 psi	10 psi
SIERRA/0.01-----	290	115	75	65
TANGO/0.03-----	410	160	105	95
UNIFORM/0.05-----	490	190	125	110
VICTOR/0.10-----	610	240	155	140
WHISKEY/0.30-----	890	350	225	200
ALFA/0.5-----	1,050	410	270	240
BRAVO/1-----	1,325	520	340	300
DELTA/5-----	2,275	890	580	510
ECHO/10-----	2,875	1,120	730	640
GOLF/50-----	4,925	1,920	1,250	1,100
HOTEL/100-----	6,200	2,400	1,600	1,400

Table 11-8. Troop Safety Distances*

Yield kt	Minimum distance (meters) required for troop vulnerability and degree of risk shown **								
	Unwarned exposed personnel			Warned exposed personnel			Warned protected personnel		
	NEG Risk	MOD Risk	EMER Risk	NEG Risk	MOD Risk	EMER Risk	NEG Risk	MOD Risk	EMER Risk
SIERRA/0.01	1,000	900	800	1,000	900	800	900	700	625
TANGO/0.03	1,150	1,050	925	1,150	1,050	925	950	725	650
UNIFORM/0.05	1,200	1,100	975	1,200	1,100	975	975	775	700
VICTOR/0.10	1,300	1,200	1,050	1,300	1,200	1,050	1,075	850	800
WHISKEY/0.30	1,350	1,250	1,100	1,390	1,250	1,100	1,100	900	850
ALFA/0.5	1,500	1,300	1,150	1,500	1,300	1,150	1,200	1,000	900
BRAVO/1.0	1,700	1,400	1,300	1,700	1,400	1,300	1,400	1,200	1,100
DELTA/5.0	2,100	1,700	1,550	2,100	1,700	1,550	1,700	1,400	1,300
ECHO/10.0	2,600	1,900	1,600	2,200	1,400	1,750	1,800	1,500	1,400
GOLF/50.0	4,900	3,800	3,300	3,200	2,300	1,900	2,400	1,800	1,700
HOTEL/100.0	6,400	5,000	4,400	4,200	2,700	2,200	3,000	2,300	2,000

*Initial effects only, surface burst.

**Yields for which radiation is the governing troop safety criteria.

Yield (kt)	Exposed		Protected
	Unwarned	Warned	Warned
Less than 8	Yes	Yes	Yes
8-15	No	Yes	Yes
16-200	No	No	No

Yes—Radiation is governing criteria.

No—Radiation is not governing criteria.

Table 11-9. Light Aircraft in Flight for Surface Burst ¹

Yield kt	Aircraft safety radii—meters ²		
	Light fixed wing	Recon and obsn hel	Transport and util hel
SIERRA/0.01 -----	1400	1500	1400
TANGO/0.03 -----	1600	1600	1600
UNIFORM/0.05 -----	2000	2000	1900
VICTOR/0.10 -----	2600	2600	2500
WHISKEY/0.30 -----	3000	3000	3000
ALFA/0.5 -----	4000	4000	4000
BRAVO/1 -----	5000	5000	5000
DELTA/5 -----	9000	9000	7000
ECHO/10 -----	10000	10000	9000
GOLF/50 -----	17000	16000	15000
HOTEL/100 -----	22000	21000	18000

¹ These radii apply to contact surface bursts. See FM 101-31-1.² A buffer distance has been added to these radii of safety.

APPENDIX III

BLAST AND GROUND SHOCK DAMAGE CRITERIA

Table III-1. Damage to Types of Structures Primarily Affected by Blast-wave Overpressure During the Diffraction Phase

Description of structure	Description of damage		
	Severe	Moderate	Light
Multistory blast-resistant reinforced-concrete building with reinforced-concrete walls, designed for 30-psi Mach-region pressure from 1 mt, no windows.	Walls shattered, severe frame distortion, incipient collapse.	Walls breached or on the point of being so, frame distorted, entranceways damaged, doors blown in or jammed, extensive spalling of concrete.	Same cracking of concrete walls and frame.
Multistory reinforced-concrete building with concrete walls, small window area, three to eight stories.	Walls shattered, severe frame distortion, incipient collapse.	Exterior walls badly cracked, interior partitions badly cracked or blown down, structural frame permanently distorted, extensive spalling of concrete.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, brick-apartment-house type, up to three stories.	Bearing walls collapse, resulting in total collapse of structure.	Exterior walls badly cracked, interior partitions badly cracked or blown down.	Windows and doors blown in, interior partitions cracked.
Multistory wall-bearing building, monumental-type, up to four story.	Bearing walls collapse, resulting in collapse of structure supported by these walls; some bearing walls may be shielded enough by intervening walls so that part of the structure may receive only moderate damage.	Exterior walls facing blast badly cracked, interior partitions badly cracked, although toward far end of building damage may be reduced.	Windows and doors blown in, interior partitions cracked.
Wood frame building, house-type, one or two stories.	Frame shattered so that for the most part collapsed.	Wall framing cracked, roof badly damaged, interior partitions blown down.	Windows and doors blown in, interior partitions cracked.

Table III-2. Damage to Types of Structures Primarily Affected by Dynamic Pressure During the Drag Phase

Description of structure	Description of damage		
	Severe	Moderate	Light
Light-steel-frame industrial building, single-story, with up to 5-ton crane capacity; low-strength walls fail quickly.	Severe distortion collapse of frame.	Some to major distortion of frame; cranes if any not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy-steel-frame industrial building, single-story, with 25- to 50-ton crane capacity; lightweight low-strength walls fail quickly.	Some distortion to collapse of frame.	Some distortion to frame; cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Heavy-steel-frame industrial building, single-story, with 60- to 100-ton crane capacity; lightweight low-strength walls fail quickly.	Severe distortion collapse of frame.	Some distortion to frame; cranes not operable until repairs made.	Windows and doors blown in, light siding ripped off.
Multistory steel-frame office-type building, three- to ten-story; lightweight low-strength walls fail quickly; earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory steel-frame office-type building, three- to ten-story; lightweight low-strength walls fail quickly; non-earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Multistory reinforced-concrete-frame office-type building, three- to ten-story; lightweight low-strength walls fail quickly; earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down; some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.

Table III-2. Damage to Types of Structures Primarily Affected by Dynamic Pressure During the Drag Phase (cont.)

Description of structure	Description of damage		
	Severe	Moderate	Light
Multistory reinforced concrete-frame office-type building, three- to ten-story; light weight low-strength walls fail quickly; non-earthquake-resistant construction.	Severe frame distortion; incipient collapse.	Frame distorted moderately; interior partitions blown down; some spalling of concrete.	Windows and doors blown in, light siding ripped off, interior partitions cracked.
Highway truss bridges, spans 150 to 250 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Railroad truss bridges, spans 150 to 250 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Highway and railroad truss bridges, spans 250 to 500 ft.	Total failure of lateral bracing; collapse.	Some failure of lateral bracing such that bridge capacity is reduced about 50 percent.	Capacity of bridge unchanged, slight distortion of some components.
Floating bridges, U.S. Army standard M3 and M-4, random orientation.	All anchorages torn loose, connections between treadways or balk and floats twisted and torn loose, many floats sunk.	Many bridle lines broken, bridge shifted on abutments, some connections between treadways or balk and floats torn loose.	Some bridle lines broken, bridge capacity unimpaired.

Table III-3. Damage Criteria for Special Underground Structures

Structure	Damage	Damage distance *	Remarks
Relatively small, heavy, well-designed underground targets.	Severe -----	$1\frac{1}{4}R_A$	Collapse.
	Light -----	$2R_A$	Of little or no importance structurally.
Relatively long, flexible targets, such as buried pipelines, tanks.	Severe -----	$1\frac{1}{2}R_A$	Deformation and rupture.
	Moderate -----	$2R_A$	Slight deformation and rupture.
	Light -----	$2\frac{1}{2}$ to $3R_A$	Of little or no importance structurally.

* R_A is the apparent crater radius.

Table III-4. Damage Criteria for Field Fortifications

Description of structure	Description of damage		
	Severe	Moderate	Light
Command post and personnel shelter, modular sections 6' X 8' with top 3' to 5' below ground surface, earth covered, and covered trench entrance.	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken moderate displacement, some revetment failure.	Damage to minor components only slight displacement, occasional revetment failure.
Machine-gun emplacement, 7' X 7', framework extends 2' above original ground surface, has open firing ports and open trench entrance; 3' to 5' mound of earth covers framework and extends down to the ground surface except at openings. *	Caps and posts broken, large displacement and disarrangement of timbers, revetment failure.	Some caps and posts broken, moderate displacement, some revetment failure.	Damage to minor components only slight displacement, occasional revetment failure.
Unrevetted trenches and foxholes with or without light cover.	The trench or foxhole is at least 50 percent filled with earth.	The trench or foxhole is at least 10 percent but less than 50 percent filled with earth.	The trench or foxhole is less than 10 percent filled with earth.

* Post, cap, and stringer construction, timber approximately 6" X 8", or 12" in diameter.

APPENDIX IV

RECOMMENDED FORMS AND FORMATS

A4-1. General

a. This appendix contains the following ADM forms and formats:

- (1) Atomic Demolition Plan.
- (2) Request for Atomic Demolition Munitions Support (DA Form 3064-R).
- (3) Orders to the Demolition Guard Commander and Demolition Firing Party Commander (STANAG 2017).
- (4) Atomic Demolition Munition Firing Order, (DA Form 3065-R).

(5) ADM Annex for an Engineer Unit SOP.

(6) ADM Reconnaissance Record (DA Form 3066-R).

b. The use of the above forms and formats is discussed in chapters 3 and 4. When completed, the security classification of each form is noted in accordance with AR 380-5.

c. DA Forms 3064-R, 3065-R and 3066-R will be reproduced locally on 8-X 10-1/2-inch paper and may be printed on as many pages as necessary.

A4-2. Format for Atomic Demolition Plan

(Classification)

Copy Number
Issuing Headquarters
Location
Date-Time
Reference Number

APPENDIX.....(Atomic Demolition Plan) to
ANNEX.....(Engineer Annex) to OPERATIONS
PLAN.....
or
ANNEX.....(Barrier Plan) (Denial Plan) to
OPERATIONS PLAN.....
ANNEX.....(Fire Support Plain) to OPERATIONS
PLAN.....

REFERENCES: Maps, Overlays, etc.

(Classification)

 (Classification)
1. SITUATION

a. Enemy Forces. (Refer to applicable Intelligence Annex.)

b. Friendly Forces. (Refer to operation order.)

c. Atomic Demolition Capabilities

(1) Available emplacement units.

(2) ADM allocations. (List by type and yield the ADM allocated. Tabular listings are appropriate.)

2. MISSION (Simple statement of ADM mission.)

3. EXECUTION

a. Concept of Operation.

b. Designation of delivery units(s) and detailed instructions as to—

(1) Target designation (code word or number).

(a) Target location and description.

(b) Type and yield ADM, point of detonation, or DOB, location of ground zero.

(c) Time of emplacement and final arming.

(d) Security: designation of unit to be demolition guard.

(2) (Use a separate numbered subparagraph for each ADM target included, or a tabular listing may be used and reference made to the proper TAB.)

c. Designation of supporting units and de-

tailed coordinating instructions as to —

(1) Target designation.

(a) Warning and/or evacuation of friendly military forces and civilian population.

(b) Coordination required among tactical commanders.

(c) Time of detonation or circumstances under which ADM is to be fired.

(d) Method(s) of firing.

(e) Authority to fire or safe munition.

(f) Authority to change or cancel mission, and to institute emergency evacuation and/or destruction.

(2) (Use a separate numbered subparagraph for each ADM target or a tabular listing and refer to the TAB.)

4. ADMINISTRATION AND LOGISTICS

a. Reference should be made here to the applicable Administrative Order.

b. Indicate here any specific logistical instructions applicable to the ADM mission.

5. COMMAND AND SIGNAL

a. Specific instructions as to command control and the aspects of command site(s), e.g., selection, location, security, etc.

b. Special communications requirements.

ACKNOWLEDGMENT INSTRUCTIONS**TABS****DISTRIBUTION****AUTHENTICATION**

 (Commander)

 (Classification)

REQUEST FOR ATOMIC DEMOLITION MUNITIONS SUPPORT (FM 5-26)		TARGET NUMBER
PART I - REQUEST FOR ATOMIC DEMOLITION MUNITIONS		TO (from)
EXPLANATION OF TERMS	LETTER DESIGNATION	TIME SENT (rec)
A. WARNING - The initial element of the message indicates that a request for ADM support follows. Code words differentiate between targets of opportunity and preplanned targets.	ALFA	A.
B. NATURE OF TARGET - The description of the target is as complete as possible for target analysis. If an area target, size designated by limiting coordinates or by a target radius in meters. Details of design and construction (for structures) or required crater dimensions are indicated for point targets. Target destruction is the usual desired damage for ADM attack. If neutralization is desired, so designate.	BRAVO	B.
C. DESIRED GROUND ZERO - Location is expressed in UMT coordinates to the nearest 10 meters.	CHARLIE	C.
D. POINT OF DETONATION OR DEPTH OF BURST - The desired depth is expressed as the number of meters below the surface or as a SURFACE burst.	DELTA	D.
E. YIELD - The desired yield is based on the nature of the target and is expressed in kilotons. Fractional yields are expressed as hundredths of a kiloton. For example: 0.01 would be expressed as ZERO POINT ZERO ONE.	ECHO	E.
F. TIME ON TARGET (TOT) - Time on target is based on the nature of the target and the scheme of maneuver. Time is expressed in local time as a seven digit date-time group or as on call; e.g. 011600Z.	FOXTROT	F.
G. FIRING OPTIONS - The desired method and alternate methods of detonation in descending priority are indicated.	GOLF	G.
H. TROOP SAFETY REQUIREMENTS - Troop safety is based on planned disposition of friendly troops at time of burst. Disposition may be expressed as a series of coordinates, a pre-arranged phase line, or a radius and distance from ground zero.	HOTEL	H.
I. TYPE OF ANALYSIS - If a target analysis has been performed by the requesting unit, the type of analysis performed is specified as visual, numerical, or special ADM.	INDIA	I.
J. SUPPORT REQUIRED - If the requesting unit does not possess an ADM capability, the number of ADM teams required are requested. If additional engineer emplacement personnel and equipment are needed, they are requested. If special transportation of the ADM to the emplacement site (e.g., aerial delivery) is desired, such means are requested.	JULIET	J.
K. REMARKS - Add any additional information required. For example, the desired time of burst may be expanded in this column to indicate the earliest or latest permissible times of burst.	KILO	K.
PART II - CONCURRENCES AND COORDINATION		
1. RELEASING COMMANDER		
☐ APPROVED ☐ DISAPPROVED _____ TIME _____ BY _____ INITIALS _____		
DESIGNATION OF EXECUTING UNIT		AUTHORITY TO FIRE DELEGATED TO:
REMARKS (Modifications to or reasons for disapproval of ADM request)		
2. STAFF CONCURRENCES		
	TIME/INITIALS	TIME/INITIALS
G2		FSCC
G3		ALO
G4		CBRE
Adj HQS		Engr (fallout prediction)

DA FORM 3064-R, 1 Nov 65

Figure IV-1. DA Form 3064-R.

3. NOTIFICATION HIGHER HEADQUARTERS		
TIME OF NOTIFICATION	REQUEST FORWARDED TO: <i>(For action - name of higher headquarters)</i>	
ACTION TAKEN	EMPLACEMENT AND SUPPORT UNITS	TO BE FIRED AT:
REMARKS		
4. SUBORDINATE AND SUPPORTING UNITS		
a. TIME EMPLACEMENT AND SUPPORTING UNITS NOTIFIED		
(1) DESIGNATION OF EXECUTING UNIT	(2) ADM AND YIELD	
(3) TIME AND/OR METHOD OF FIRING	(4) RENDEZVOUS POINT WITH DEMOLITION GUARD <i>(coordinates)</i>	
(5) RENDEZVOUS TIME	(6) SPECIAL EQUIPMENT REQUIREMENTS	
(7) SECURITY REQUIREMENTS	(8) METHOD OF TRANSPORTATION	
(9) REMARKS		
b. TIME REQUESTING UNIT NOTIFIED		
(1) MISSION ☐ APPROVED ☐ DISAPPROVED		
(2) DESIGNATION OF EXECUTING UNIT	(3) CONTROL AND FIRING DELEGATED TO	
(4) SECURITY REQUIREMENTS	(5) RENDEZVOUS POINT WITH EMPLACEMENT ELEMENTS	
(6) REMARKS		
c. WARNING <i>(time)</i>		
(1) ARMY AVN	(2) TAF	(3) TROOP UNITS
5. TACTICAL DAMAGE ASSESSMENT		
GROUND ZERO	ODB DR HDB	YIELD
REMARKS		

Figure IV-1 — Continued

★A4-4. ORDERS TO THE DEMOLITION GUARD COMMANDER AND DEMOLITION FIRING PARTY COMMANDER (STANAG 2017 and SEASTAG 2017)

STANAG NO. 2017

(Edition No. 2)

5 October/octobre 1964

**NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD
MILITARY AGENCY FOR STANDARDIZATION
BUREAU MILITAIRE DE STANDARDISATION
STANDARDIZATION AGREEMENT
ACCORD DE STANDARDISATION**

SUBJECT

OBJET

**ORDERS TO THE DEMOLITION GUARD COMMANDER
AND DEMOLITION FIRING PARTY COMMANDER**

**CONSIGNES AU CHEF DU DETACHEMENT DE PROTECTION D'UN OUVRAGE A
DETRUIRE ET AU CHEF DU DETACHEMENT DE MISE**

EN OEUVRE D'UNE DESTRUCTION

DETAILS OF AGREEMENT (DofA)

**ORDERS TO THE DEMOLITION GUARD COMMANDER AND
DEMOLITION FIRING PARTY COMMANDER**

Enclosures: Annex 'A' (DofA)—Orders to the Demolition Guard Commander.

Annex 'B' (DofA)—Orders to the Demolition Firing Party Commander.

GENERAL

1. It is agreed that the following procedures will be used by the NATO Armed Forces to issue orders to the Demolition Guard Commander and to the Demolition Firing Party Commander in connection with demolition operations on land. In the case of opportunity demolitions a simplified procedure may be used.

2. Three commanders are normally concerned with the execution of a demolition—

a. The military authority who has overall responsibility, i.e., the officer empowered to order the firing of the demolition (referred to hereafter as "The Authorized Commander").

b. The Demolition Guard Commander.

c. The Demolition Firing Party Commander in technical charge of the preparation, charging and firing of the demolition.

PROCEDURE

3. Each Authorized Commander will—

a. Determine the requirement and allot responsibility for a Demolition Guard;

b. Establish a clear cut channel whereby the

order to fire the demolition is transmitted from himself to the Demolition Guard Commander;

c. Ensure that this channel is known and understood by all concerned;

d. Ensure a positive, secure means for transmitting the order to fire;

e. Specify whether the Demolition Guard Commander is authorized to order the firing of the demolition on his own initiative if the enemy is in the act of capturing it.

4. Where a demolition is to be prepared which is important to the operational plan, the Authorized Commander will normally appoint a Demolition Guard, the Commander of which will be responsible for—

a. Ensuring, if so ordered, that the demolition is not captured intact by the enemy;

b. Giving to the Demolition Firing Party Commander the orders for changing the state of readiness of the demolition and the firing orders.

5. Instructions in respect of the Demolition Guard Commander are at Annex 'A' (DofA) and instructions in respect of the Demolition Firing Party Commander are at Annex 'B'

(DofA). These forms will be used whenever time and conditions permit.

6. After all parts of the form at Annex 'A' (DofA) have been completed by the appropriate authority, the form will be issued to the Demolition Guard Commander and will be retained by him until the demolition has been completed.

7. After Parts I, II and III of the form at Annex 'B' (DofA) have been completed by the appropriate authority, the form will be issued to the Demolition Firing Party Commander and will be retained by him until the demolition has been fired.

8. The contents and paragraph numbers of the forms issued by each national authority will conform exactly to the examples at Annex 'A' (DofA) and Annex 'B' (DofA). The forms

issued by each national authority should also conform as closely as possible, both in size and shape, to these examples. It is preferable that the forms should be printed on heavy durable paper which at the same time is thin enough to allow a carbon copy to be made; the colour should be yellow for the form at Annex 'A' (DofA) and white for that at Annex 'B' (DofA).

9. To facilitate the use of these standard NATO forms, it is recommended that certain general instructions to Demolition Guard Commanders and Demolition Firing Party Commanders be included in appropriate unit Standing Operating Procedures/Standing Orders. The most important of these instructions have been included in Part VII of Annex 'A' (DofA) and Part V of Annex 'B' (DofA).

**ANNEX 'A' (D of A) of STANAG 2017
(Edition No. 2)**

Serial No. _____

Security Classification _____

ORDERS TO THE DEMOLITION GUARD COMMANDER

- Notes:** 1 This form will be completed and signed before it is handed to the Commander of the Demolition Guard.
2. In completing the form, all spaces must either be filled in or lined out.
3. The officer empowered to order the firing of the demolition is referred to throughout as the "Authorized Commander."

From _____ To _____

PART I—PRELIMINARY INSTRUCTIONS

1.
 - a. Description of target _____
 - b. Location :
Map Name and Scale _____ Sheet No. _____
Grid Reference _____
 - c. Code word or code sign (if any) of demolition target _____
2. The Authorized Commander is _____
(given appointment only). If this officer should delegate his authority you will be notified by one of the methods shown in paragraph 4, below.
3. The DEMOLITION FIRING PARTY COMMANDER has been/will be provided by _____
4. All messages, including any code words or code signs (if any) used in these orders, will be passed to you by :
 - a. normal command wireless net, or
 - b. special liaison officer with communications direct to the Authorized Commander, or
 - c. telephone by the Authorized Commander, or
 - d. the Authorized Commander personally, or
 - e. _____

(Delete those NOT applicable)

Note: All orders sent by message will be prefixed by the code word or code sign (if any) at paragraph 1c and all such messages must be acknowledged.

PART II—CHANGING STATES OF READINESS

5. The demolition will be prepared initially to the State of Readiness _____ by _____ hours, on _____ (date).
6. On arrival at the demolition site, you will ascertain from the Commander of the Demolition Firing Party the estimated time required to change from State "1" (SAFE) to State "2" (ARMED). You will ensure that this information is passed to the Authorized Commander and is acknowledged.
7. Changes in the State of Readiness from State "1" (SAFE) to State "2" (ARMED) or from State "2" to State "1" will be made only when so ordered by the Authorized Commander. However, the demolition may be ARMED in order to accomplish emergency firing when you are authorized to fire it on your own initiative.

8. A record of the changes in the State of Readiness will be entered by you in the table below, and on the firing orders in possession of the commander of the demolition firing party.

State of Readiness ordered "1" (SAFE) or "2" (ARMED)	Time and date change to be completed	Authority	Time and date of receipt of order

Note: If the order is transmitted by an officer in person, his signature and designation will be obtained in the column headed "Authority."

9. You will report completion of all changes in the State of Readiness to the Authorized Commander by the quickest means.

PART III—ORDERS FOR FIRING THE DEMOLITION

10. The order for firing the demolition will be passed to you by the Authorized Commander.

11. On receipt of this order you will immediately pass it to the Commander of the Demolition Firing Party on his demolition orders form ("Orders to the Demolition Firing Party Commander").

12. After the demolition has been fired you will report the results immediately to the Authorized Commander.

13. In the event of a misfire or only partially successful demolition you will give the firing party protection until such time as it has completed the demolition and report again after it has been completed.

PART IV—EMERGENCY FIRING ORDERS

Notes: 1. One sub-paragraph of paragraph 14 must be deleted.

2. The order given herein can only be altered by the issue of a new form, or, in emergency by the appropriate order (or code word if used) in Part V.

14. a. You will order the firing of the demolition only upon the order of the Authorized Commander, or
- b. If the enemy is in the act of capturing the target you will order the firing of the demolition on your own initiative.

PART V—CODE WORDS (IF USED)

	Action to be Taken	Code Word
a.	Change State of Readiness from "1" to "2" (see paragraph 7)	
b.	Change State of Readiness from "2" to "1" (see paragraph 7)	
c.	Fire the demolition (see paragraph 10)	
d.	Paragraph 14.a. is now cancelled. You are now authorized to fire the demolition if the enemy is in the act of capturing it.	
e.	Paragraph 14.b. is now cancelled. You will order the firing of the demolition only upon the order of the Authorized Commander.	
f.	Special authentication instructions, if any.	

PART VI

Signature of officer issuing these orders.....
 Name (printed in capital letters).....
 Rank..... Appointment.....
 Time of issue.....hours,(date).

**PART VII—DUTIES OF THE COMMANDERS OF THE
DEMOLITION GUARD**

15. You are responsible for :—
 - a. Command of the demolition guard and the demolition firing party.
 - b. The safety of the demolition from enemy attack or sabotage.
 - c. Control of traffic and refugees.
 - d. Giving the orders to the demolition firing party in writing to change the state of readiness.
 - e. Giving the orders to the demolition firing party in writing to fire the demolition.
 - f. After the demolition, reporting on its effectiveness to the Authorized Commander.
 - g. Keeping the Authorized Commander informed of the operational situation at the demolition site.
16. You will acquaint yourself with the orders issued to the Commander of the Demolition Firing Party and with the instructions given by him.
17. The Demolition Guard will be so disposed as to ensure at all time complete all-round protection of the demolition against all types of attack or threat.
18. The commander of the Demolition Firing Party is in technical control of the demolition. You will agree with him the site of your HQ and of the firing point. These should be together whenever practicable. When siting them you must give weight to the technical requirements of being able to view the demolition and have good access to it from the firing point.
19. You will nominate your deputy forthwith and compile a seniority roster. You will ensure that each man knows his place in the roster, understands his duties and knows where to find this form if you become a casualty or are unavoidably absent. The seniority roster must be made known to the Commander of the Demolition Firing Party.
20. Once the State of Readiness "2 ARMED" has been ordered, either you or your deputy must always be at your HQ so that orders can be passed on immediately to the Commander of the Demolition Firing Party.

ANNEX "B" (D of A) of STANAG 2017
(Edition No. 2)

Serial No. _____ Security Classification _____

**ORDERS TO THE
DEMOLITION FIRING PARTY COMMANDER**

NOTES:—Parts I, II and III will be completed and signed before this card is handed to the Demolition Firing Party Commander. Paras. 4 and 5 can only be altered by the authority issuing these orders. In such cases a new form will be issued and the old one destroyed.

From _____ To _____

**Part I—Orders for preparing and charging the
demolition target**

1. a. Description _____

b. Location:—
Map Name and Scale _____
Sheet No. _____ Grid Reference _____
c. Code word of Demolition Target (if any) _____
d. Attached photographs and special technical instructions _____

2. The DEMOLITION GUARD is being provided by (Unit) _____
3. You will prepare and charge the demolition target to the STATE OF READINESS _____
by _____ hours on _____ (date).
Any changes may only be made on the order of the issuing authority, or by the officer designated in para. 4.d. and will be recorded below.

State of Readiness: Ordered "1 (Safe)" or "2 (Armed)"	Time and date change to be completed	Authority	Time and date of receipt of order

NOTE:—All orders received by message will be verified by the code word at para. 1.c. If the order is transmitted by an officer in person, his signature and designation will be obtained in the column headed "Authority".

B (D of A)—1

NATO—UNCLASSIFIED

Security Classification _____

Part II—Orders For Firing

NOTE:—The officer issuing these orders will strike out the sub-para. of paras. 4 and 5 which are not applicable. When there is a Demolition Guard, sub-para. 4.d. will always be used, and para. 5 will always be struck out.

4. a. You will fire the demolition as soon as you have prepared it.
 4. b. You will fire the demolition at _____
hours on _____ (date).
 4. c. You will fire the demolition on receipt of the code word _____
 4. d. You will fire the demolition when the officer whose designation is _____
_____ has signed para. 8 below.
- Emergency Firing Orders (ONLY applicable when there is NO Demolition Guard).**
5. YOU WILL NOT FIRE the demolition in any circumstances except as ordered in para. 4 above.
or
YOU WILL FIRE the demolition on your own initiative if the enemy is in the act of capturing it.

Part III—Orders for Reporting

6. After firing the demolition you will immediately report results to the officer who ordered you to fire. In the event of a partial failure, you will warn him, and immediately carry out the work necessary to complete the demolition.
7. Finally you will immediately report the results to your Unit Commanding Officer (see para. 13).
Signature of Officer _____
issuing these orders _____
Name (in capitals) _____
Designation _____
Time of issue _____
Date of issue _____

Part IV—Order to Fire

8. Being empowered to do so I order you to fire NOW the demolition described in para. 1.
Signature _____
Name (in capitals) _____
Designation _____
Time _____
Date _____

NATO—UNCLASSIFIED

B (D of A)—2

READ THESE INSTRUCTIONS CAREFULLY

Part V—General Instructions

9. You are in technical charge of the preparation, charging and firing of the demolition target described. You will nominate your deputy forthwith, and compile a seniority roster of your party. You will ensure that each man knows his place in the roster, understands these instructions, and knows where to find this form if you are hit or unavoidably absent. You will consult with the Demolition Guard Commander on the siting of the firing point.
10. You must understand that the DEMOLITION GUARD Commander (where there is one) is responsible for:—
 - a. Operational command of ALL troops at the demolition site. (You are therefore under his command).
 - b. Preventing the capture of the demolition site, or interference by the enemy with demolition preparations.
 - c. Controlling all traffic and refugees.
 - d. Giving you the order to change the STATE OF READINESS from ("1 SAFE") to "2 (ARMED)" or back to "1 (SAFE)" again. You will inform him of the time required for such a change.
 - e. Passing to you the actual order to fire.
11. When there is no demolition guard and you are instructed in para. 4 to accept the order to fire from some particular officer, it is important that you are able to identify him.
12. If you get orders to fire other than those laid down in para. 4 you should refer them to the Demolition Guard Commander or if there is no Demolition Guard Commander, to your immediate superior. If you cannot do this, you will ONLY depart from your written instructions when you are satisfied as to the identity and over-riding authority of whoever gives you these new orders, and you will get his signature in para. 8 whenever possible.
13. The report to your Unit Commanding Officer, as called for in para. 7 should contain the following information (where applicable):—
 - a. Identification reference of demolition.
 - b. Map reference.
 - c. Time and date when demolition was fired.
 - d. Extent of damage accomplished, including:—

Estimated width of gap	In the case of a bridge.
Number of spans down	
Size and location of craters in a road or runway	
Mines laid	
Sketch showing effect of demolition.	

B (D of A)—3

Note. This format is modified for ADM operations; see paragraph AIV-5.

★A4-5. Format for Orders to the ADM Firing Party Commander (DA Form 3065-R)

(Security Classification)

ATOMIC DEMOLITION MUNITION FIRING ORDER NO. _____			
This order is for ADM employment only.			
To (US) ADM Firing Party Commander			
You will fire target identified below in accordance with the following instructions. The Mission Officer (par 3b, c) is the representative of the Executing Commander. He is in command of this ADM mission. You will accept any additional instructions or changes from him.			
1. TARGET			
a. Location (Coordinates)	b. Codeward or Target Number		
c. Description			
2. MUNITION DATA			
a. Type and Yield ADM	b. Present location of munition		
3. CONTROL			
a. Executing Commander	b. Mission Officer	c. Alternate	
4. EMPLACEMENT DATA (Check one and fill in description)			
a. ☐ Surface emplacement	d. Description of precise position of ADM on target.		
b. ☐ Emplacement above surface _____ meters			
c. ☐ Emplacement below surface _____ meters			
5. FIRING OPTIONS DESIRED			
a. Primary	☐ Timer	or	☐ Remote (Specify)
b. 1st Alternate	☐ Timer	or	☐ Remote (Specify)
c. 2nd Alternate	☐ Timer	or	☐ Remote (Specify)
6a. FIRING SITE		6b. ALTERNATE	
7. DETONATION (Complete where necessary)			
☐ a. ASAP	☐ b. On order	☐ c. Detonate at	_____
d. If munition is emplaced on target you will detonate to prevent capture			☐ Yes ☐ No

DA FORM 3065-R
1 Dec 68

(Security Classification)

Replaces edition of 1 Nov 65, which is obsolete.

★Figure IV-2. DA Form 3065-R.

(Security Classification)

8. SECURITY REQUIREMENTS			
o. Security force		b. Rendezvous point and time	
9. OTHER INSTRUCTIONS			
(NOTE: Include codewords for possible mission change orders, such as, orders to fire the ADM or abort the mission or to improve the readiness.)			
10. AUTHENTICATION		DTG:	
By order of		Signature	
11. RECEIPT ACKNOWLEDGED Signature of ADM Firing Party Commander			
12. CHANGES			
o. Description of change	Time ordered	Time completed	Signature of mission officer
b. Description of change			Signature of mission officer
c. Description of change			Signature of mission officer
13. EXECUTION			
o. Mission executed at			
b. Remarks			
Signature of ADM Firing Party Commander		Signature of Mission Officer	
MINIMUM DISTRIBUTION			
1. Original to ADM Firing Party Commander			
2. Copy to Mission Officer			
3. Copy to Executing Commander			

(Security Classification)

★Figure IV-2—Continued.

A4-6. Suggested ADM Unit SOP Format*

(Classification)

XXth Engineer Bn
Fort Belvoir, Virginia
(date)

ANNEX E—Atomic Demolition Munitions (ADM)**1. APPLICATION**

This SOP supersedes all previous SOP and applies except as modified by battalion orders. Subordinate unit SOP will conform. Attached units will comply with this SOP.

2. REFERENCES

(List SOP, directives and/or policies of higher headquarters on which this SOP is based.)

3. ADMINISTRATION*a. Responsibilities.*

(1) For preparation and periodic review of the SOP.

(2) For requisitioning and posting of changes to all pertinent publications.

b. Records and Reports.

(1) (List required reports to higher headquarters.)

(2) (List required test and maintenance records as specified by pertinent manuals.)

(3) Instructions on Tactical Damage Evaluation Reports.

★4. PUBLICATIONS*a. Requisitioning Procedure.**b. Reference Material—Appendix 1.**c. Unsatisfactory Reports.*

(1) Preparation and study of proposals.

(2) Submission and review procedures.

(3) Ammunition Condition Report (DA Form 2415) and Equipment Improvement Report.

(4) Recommended changes to DA publications (DA Form 2028).

5. SUPPLY*a. Authority (TOE, TA, TD, EMR, etc.).*

b. Equipment Lists (Refer to the appropriate parts list).

c. Requisition procedures (including local requirements).

d. Property accountability (including local requirements).

6. SAFETY*a. General.*

(1) A statement allowing no deviation from the approved checklist.

(2) Applicable safety requirements deemed necessary. (Preventive maintenance, driver training, preoperational vehicle checks, etc.)

*b. Electrical Safety requirements.**c. Explosive Safety requirements.**d. Nuclear Safety requirements.**e. Disposal of contaminated material.***7. TRAINING**

ADM training should be conducted in the following areas:

*a. Prefire Procedures.**b. Command Site Preparation.**c. Formal Instruction.*

(1) Classroom presentation.

(2) Manual study.

(3) Review of SOP and demolition fire orders (DFO).

d. Support Training.

(1) Convoy procedure.

(2) Emplacement site preparation.

(3) Team organization.

(4) Site security.

8. SECURITY*a. Statement of Policy.*

(1) Importance.

(2) Possible consequence of violations.

(3) Responsibilities.

*b. Document Control.**c. Classified Item Control.**d. Classified Study Procedures.**e. Clearances—Appendix 2.*

(Classification)

*Applicable portions are also pertinent for engineer units below battalion.

(Classification)

f. Access List—Appendix 3.

★9. TRANSPORTATION

a. Convoy Composition (list 3 or 4 different types; do not attempt to standardize beyond minimum requirements). List these as type I, type II, etc., so that the assemblyman, when instructed as to convoy type for a particular operation, may refer to the ADM SOP.

b. Air Movement Plans. (List details of ADM movement by aircraft to include security and handling requirements.)

c. Personnel and Duties. (List duties and required clearances.)

(1) Courier Officer (OIC—may also be convoy commander).

(2) Convoy Commander.

(3) Guard Force.

d. Control.

(1) Convoy coordination.

(2) Coordination with tactical security forces.

(3) Procedures in case of unavoidable delay or mechanical breakdown. (Other than an accident or incident.)

10. ORGANIZATION FOR ADM MISSIONS

Note. This paragraph outlines a suggested organization of the ADM firing party for conduct of an ADM mission. Missions in support of allied forces will require modifications.

a. *Team Leaders.* (Indicated by position rather than name) Example: CO, EXO, Plt Ldr, Plt Sgt, Sqd Ldr, etc.

b. *Composition and Duties.*

(1) Prefire Team (for composition see table 1).

(a) Pickup of ADM equipment—Appendix 4.

(b) Transportation procedures.

(c) Prefire procedures—Appendix 5.

(d) Remote command fire procedures—Appendix 6.

(e) Basic immediate security of munition.

(f) Emergency disarm procedures—Appendix 7.

(2) Support Team (size dependent on type of mission).

(a) Pickup and transportation procedures (mines, camouflage, tentage, etc.).

(b) Preparation of the emplacement site (construction, installation of mines; wire; boobytraps; etc.).

(c) Preparation of command site(s).

(3) Security Team (size dependent on terrain, tactical situation, etc.).

(a) Provide convoy guards during the transportation phase.

(b) Establish emplacement site security prior to the arrival of the munition.

(c) Provide security at the completed emplacement site until prearranged departure time.

(d) Provide security detail at the command site until after detonation.

★11. ACCIDENT AND INCIDENT PLAN

This paragraph will cover such contingencies as accidents, incidents, or delays to include explosions, nuclear contamination, misfire malfunction, and damage.

a. *General.* It is recommended that a set of code words be prepared, if not already accomplished by higher headquarters, to allow understanding of the situation over an unclassified means of communication.

b. *Accident.*

(1) Definition. (The definition of an accident may be found in AR 385-40.)

(2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)

(3) Notification. (Person to be notified by name or duty, location, communication channel.)

(4) Continuing Action. (Protective measures, security, control, procedures for requesting Ordnance or EOD teams.)

(5) Follow Up and Reports.

c. *Incident.*

(1) Definition. (The definition of an incident may be found in AR 385-40.)

(Classification)

(Classification)

(2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)

(3) Notification. (Person to be notified by name or duty, location, communication channel.)

(4) Continuing Action. (Protective measures, security, control, procedures for requesting Ordnance or EOD teams.)

(5) Follow Up and Reports.

12. EMERGENCY DISPOSAL AND DESTRUCTION

a. Priorities of Denial.

b. Authority for Emergency Disposal and Destruction. (List chain of command having the authority to order disposal or destruction.)

c. Methods of Disposal.

d. Methods of Destruction.

e. List of Materials Needed.

APPENDIXES:

Appendix 1—List all FM, TM, TC, Ordnance Special Weapons Technical Instruction, etc., necessary for ADM Firing Party Personnel to

scan, read, or study, and the frequency of revision.

Appendix 2—List all cleared personnel within the battalion indicating their proper clearance.

Appendix 3—Include the Permanent Access List and the procedures for escorting visitors into the emplacement site.

Appendix 4—Include here a checklist of pick-up requirements. (Signature cards, SASP access requirements, documents, forms and records, ramps, lifting devices, tie down equipment, etc.).

Appendix 5—Include here a prefire checklist for each munition.

Appendix 6—Include here a checklist for remote command site (Location, foxholes, security, firing procedure, change of mission procedure, etc.).

Appendix 7—Include here a checklist for the emergency disarm of all munitions for which there is a checklist in appendix 5.

(Classification)

A4-7. Reconnaissance Record (DA Form 3066-R)

ADM RECONNAISSANCE RECORD (FM 5-26)		FILE NUMBER	DATE/TIME
SECTION I - HEADING			
	NAME AND POSITION	GRADE	ORGANIZATION
RCN ORDERED BY			
RCN CONDUCTED BY			
SECTION II - ADM TARGET REPORT NUMBER _____			
A. WARNING (Code Word)	ALFA		
B. NATURE OF TARGET (include critical dimensions and desired damage)	BRAVO		
C. GROUND ZERO (UMT grid coordinates)	CHARLIE		
D. DOB OR POINT OF DETONATION	DELTA		
E. GOVERNING NUCLEAR EFFECT	ECHO		
F. TIME OF DETONATION	FOXTROT		
G. METHODS OF FIRING	GOLF		
H. LOCATION OF FRIENDLY TROOPS	HOTEL		
I. ENGINEER SUPPORT REQUIRED	INDIA		
J. SPECIAL EQUIPMENT REQUIRED	JULIET		
K. ADDITIONAL REMARKS	KILO		
NOTE: Target sketches are shown on reverse side.			

DA FORM 3066-R, 1 Nov 65

Figure IV-3. DA Form 3066-R.

APPENDIX V

CONVERSION TABLES AND FUNCTIONS OF NUMBERS

Table V-1. Meters to feet; feet to meters

(1 Meter = 3.2808 Feet; 1 Foot = 0.3048 Meter)

Meters	Feet or Meters	Feet	Meters	Feet or Meters	Feet
0.3048	1	3.2808	15.5449	51	167.3224
0.6096	2	6.5617	15.8497	52	170.6033
0.9144	3	9.8425	16.1545	53	173.8841
1.2192	4	13.1233	16.4593	54	177.1649
1.5240	5	16.4042	16.7641	55	180.4458
1.8288	6	19.6850	17.0689	56	183.7266
2.1336	7	22.9658	17.3737	57	187.0074
2.4384	8	26.2467	17.6785	58	190.2883
2.7432	9	29.5275	17.9833	59	193.5691
3.0480	10	32.8083	18.2881	60	196.8500
3.3528	11	36.0891	18.5929	61	200.1308
3.6576	12	39.3700	18.8977	62	203.4117
3.9624	13	42.6508	19.2025	63	206.6925
4.2672	14	45.9316	19.5073	64	209.9733
4.5720	15	49.2125	19.8121	65	213.2542
4.8768	16	52.4933	20.1169	66	216.5350
5.1816	17	55.7741	20.4217	67	219.8158
5.4864	18	59.0550	20.7265	68	223.0967
5.7912	19	62.3358	21.0313	69	226.3775
6.0960	20	65.6167	21.3361	70	229.6583
6.4008	21	68.8975	21.6409	71	232.9391
6.7056	22	72.1784	21.9457	72	236.2200
7.0104	23	75.4592	22.2505	73	239.5008
7.3152	24	78.7400	22.5553	74	242.7816
7.6200	25	82.0209	22.8601	75	246.0625
7.9248	26	85.3017	23.1649	76	249.3433
8.2296	27	88.5825	23.4697	77	252.6241
8.5344	28	91.8634	23.7745	78	255.9050
8.8392	29	95.1442	24.0793	79	259.1858
9.1440	30	98.4250	24.3841	80	262.4667
9.4488	31	101.7058	24.6889	81	265.7475
9.7536	32	104.9867	24.9937	82	269.0284
10.0584	33	108.2675	25.2985	83	272.3092
10.3632	34	111.5483	25.6033	84	275.5900
10.6680	35	114.8292	25.9081	85	278.8709
10.9728	36	118.1100	26.2129	86	282.1517
11.2776	37	121.3908	26.5177	87	285.4325
11.5824	38	124.6717	26.8225	88	288.7134
11.8872	39	127.9525	27.1273	89	291.9942
12.1920	40	131.2333	27.4321	90	295.2750
12.4968	41	134.5141	27.7369	91	298.5558
12.8016	42	137.7950	28.0417	92	301.8367
13.1064	43	141.0758	28.3465	93	305.1175
13.4112	44	144.3566	28.6513	94	308.3983
13.7160	45	147.6375	28.9561	95	311.6792
14.0208	46	150.9183	29.2609	96	314.9600
14.3256	47	154.1991	29.5657	97	318.2408
14.6304	48	157.4800	29.8705	98	321.5217
14.9352	49	160.7608	30.1753	99	324.8025
15.2400	50	164.0416	30.4801	100	328.0833

Table V-2. Conversion Factors (Linear Measure)

Meters *	Inches	Feet	Yards	Miles		Kilometers	Fathoms
				Statute	Nautical **		
1.0	39.37	3.28083	1.09361	0.0006214	0.0005396	0.001	0.546
.0254	1.0	.0833	.0278	.00001578	.00001371	.0000254	.0139
.3048	12.0	1.0	.3333	.0001894	.0001645	.0003048	.167
.9144	36.0	3.0	1.0	.0005682	.0004934	.0009144	.500
5.0292	198.0	16.5	5.5	.003125	.002714	.005029	2.76
20.1168	792.0	66.0	22.0	.0125	.01085	.02012	11.0
1,609.35	63,360.0	5,280.0	1,760.0	1.0	.8684	1.6094	879.0
1,853.25	72,962.5	6,080.2	2,026.73	1.15155	1.0	1.85325	1,010.0
1,000.0	39,370.0	3,280.83	1,093.61	.6214	.5396	1.0	546.0
219.5	8,640.0	720.0	240.0	.1364	.1184	.2195	120.0
1.829	72.0	6.0	2.0	.00114	.00098	.00183	1.0

* meter = 10 decimeters = 100 centimeters = 1,000 millimeters

** A nautical mile is the length on the earth's surface of an arc subtended by one minute of angle at the center of the earth.

200	100	50
100	50	25

Table V-3. $\frac{1}{3}$ and 0.3 Power of Various Numbers

Number	(No.) $\frac{1}{3}$	(No.) 0.3	Number	(No.) $\frac{1}{3}$	(No.) 0.3	Number	(No.) $\frac{1}{3}$	(No.) 0.3
.01	.22	.25	13	2.35	2.16	450	7.66	6.28
.02	.27	.31	14	2.41	2.21	500	7.94	6.47
.03	.31	.35	15	2.47	2.25	550	8.19	6.63
.04	.34	.38	16	2.52	2.30	600	8.43	6.82
.05	.37	.41	17	2.57	2.34	650	8.66	7.00
.06	.39	.43	18	2.62	2.38	700	8.88	7.13
.07	.41	.45	19	2.67	2.42	750	9.09	7.29
.08	.43	.47	20	2.71	2.46	800	9.28	7.41
.09	.45	.49	25	2.92	2.63	850	9.47	7.58
.10	.46	.50	30	3.11	2.77	900	9.66	7.70
.20	.59	.62	35	3.27	2.91	950	9.83	7.80
.30	.67	.70	40	3.42	3.02	1000	10.00	7.94
.40	.74	.76	45	3.56	3.14	1100	10.30	8.18
.50	.79	.81	50	3.68	3.24	1200	10.60	8.40
.60	.84	.86	55	3.80	3.32	1300	10.90	8.60
.70	.89	.90	60	3.91	3.42	1400	11.20	8.80
.80	.93	.94	65	4.02	3.50	1500	11.40	8.98
.90	.97	.97	70	4.12	3.58	1600	11.61	9.12
1	1.00	1.00	75	4.22	3.66	1700	11.90	9.33
2	1.26	1.23	80	4.31	3.73	1800	12.10	9.50
3	1.44	1.39	85	4.40	3.80	1900	12.40	9.62
4	1.59	1.52	90	4.48	3.86	2000	12.60	9.77
5	1.71	1.62	95	4.56	3.92	3000	14.40	11.10
6	1.82	1.71	100	4.64	3.98	4000	15.90	12.02
7	1.91	1.79	150	5.31	4.50	5000	17.10	12.90
8	2.00	1.87	200	5.85	4.91	6000	18.20	13.60
9	2.08	1.93	250	6.30	5.24	7000	19.10	14.25
10	2.15	1.99	300	6.69	5.54	8000	20.00	14.85
11	2.22	2.05	350	7.05	5.80	9000	20.60	15.30
12	2.29	2.11	400	7.31	6.04	10000	21.50	15.80



APPENDIX VI

ADM YIELD DETERMINATION PROCEDURE FOR TARGETS DAMAGED PRINCIPALLY BY AIRBLAST

A6-1. General

ADM yield determination procedures for targets damaged principally by airblast involve both the visual and numerical methods of damage estimation. Although the procedures are similar to those developed for use with nuclear weapons, the "no delivery error" characteristic of ADM simplifies the steps involved. The ultimate objective of each method is to establish the required radius of damage. This R_D is then compared with those recorded in the damage tables (app II), and the minimum ADM yield with an R_D equal to or greater than the R_D required is selected.

A6-2. Point Targets (Numerical Method)

a. General. Single buildings, bridges, and similar structures are termed point targets. Associated with the engagement of a point target is the probability of damaging (P) the target to a desired degree. For example, an 85 percent probability ($P = 85\%$) of severe damage to the target means the target has 85 out of 100 chances of receiving severe damage and 15 out of 100 chances of receiving less than severe damage.

b. Yield Determination Procedure.

(1) Enter the point target graph extension, figure VI-1, with the desired probability of damage (P), expressed as a percentage.

(2) Intersect the diagonal line and establish the value of the d/R_D ratio.

(3) Determine the displacement distance (d).

(4) Solve for the radius of damage required: $R_D = d/\text{value of ratio}$.

(5) From the damage, appendix II, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

★*c. Illustrative Example.*

Given: The commander desires a high assurance ($P = 90\%$) of causing moderate damage to oil storage tanks located 200 meters from ground zero.

Find: The minimum surface burst ADM yield to meet the commander's guidance.

Solution:

(1) Enter figure VI-1 with $P = 90\%$.

(2) $d/R_D = .74$.

(3) $d = 200$ meters.

(4) $R_D = \frac{d}{.74} = \frac{200}{.74} = 270$ meters

(5) From table II-1, appendix II, R_D for the UNIFORM/.05 kt/ADM is 285 meters.

Answer: UNIFORM/.05 kt/ADM

★A6-3. Area Targets (Visual Method)

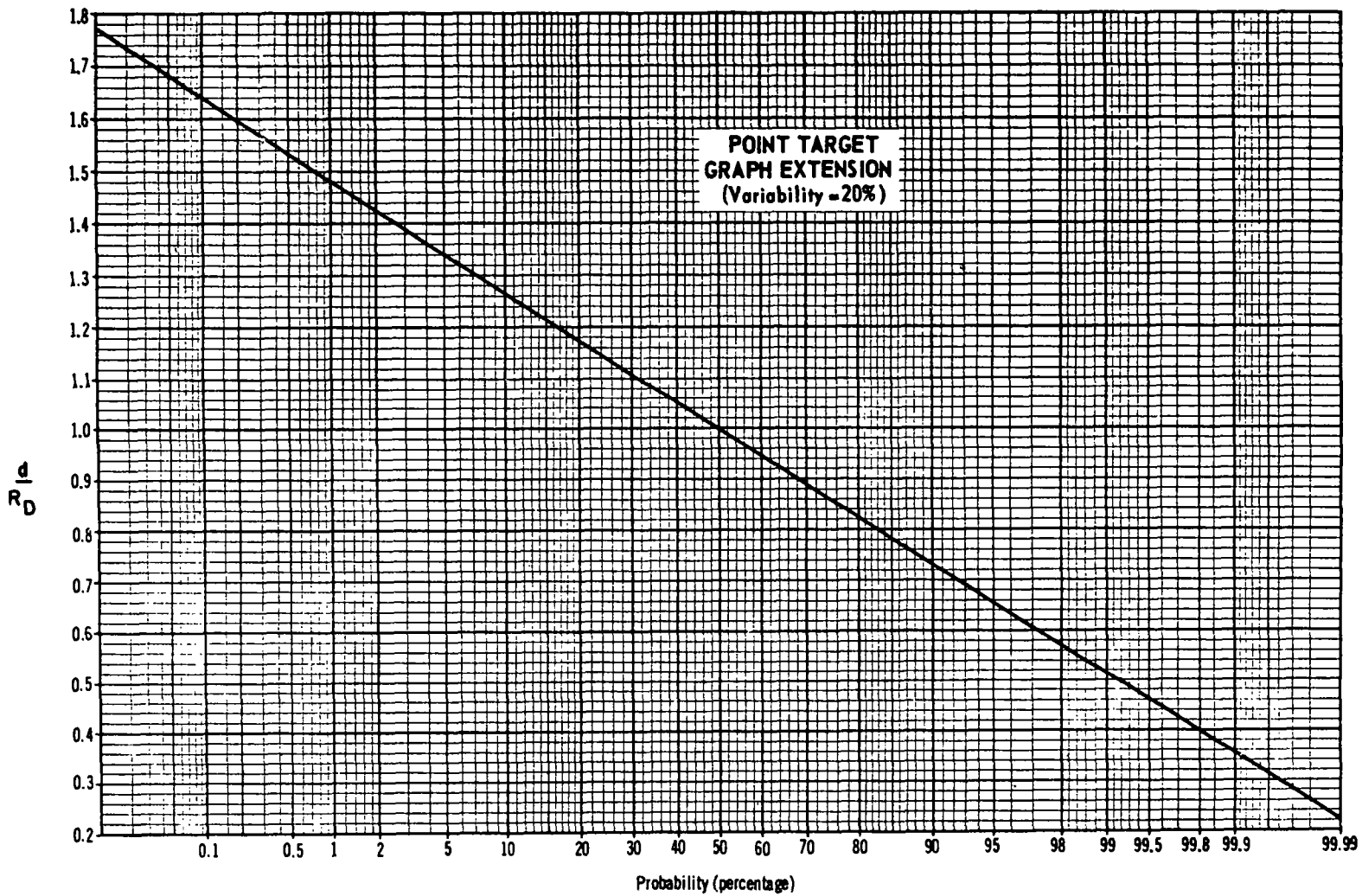
a. General. The visual method of analysis consists of a visualization of the fraction of the target covered by the radius of damage using ground zero as the reference point. In order to facilitate this visualization, a transparent circular map scale inscribed with a series of concentric circles and arcs at 100m or 200m intervals is used.

b. Yield Determination Procedure.

(1) Draw a scaled representation of the target.

(2) With a circular map scale or a comparable substitute, and using ground zero as a reference point, estimate visually the radius of damage required to achieve the fractional coverage (f) desired.

(3) Select the minimum yield which provides a radius of damage equal to or greater than the R_D required.



★Figure VI-1. Point target graph extension.

c. Illustrative Example.

Given: An engineer equipment park measures 100 meters long and 30 meters wide. The commander desires at least moderate damage to 50 percent of the target area. The situation requires the ADM to be emplaced at the entrance to the equipment park which is situated midway along the short axis.

Find: The minimum ADM yield required to meet the commander's guidance.

Solution:

(1) The engineer equipment park is drawn to scale.

(2) With the circular map scale, the required R_D is found to be slightly greater than 50 meters for at least 50 percent coverage.

(3) From table II-I the following R_D 's for moderate damage are obtained.

	SIERRA 0.01kt	TANGO 0.03kt
Engr Truck Mounted Equip -----	70m	80m
Engr Earthmoving Equip -----	45m	55m

The TANGO/.03kt/ADM is the minimum yield which meets the commander's requirements.

Answer: TANGO/.03kt/ADM

★A6-4. Area Targets (Numerical Method)

a. General. The numerical method of analysis may be used with either circular or approximately circular targets. Ground zero may be at or displaced some distance (d) from target center. The numerical method requires the use of the ADM fractional coverage nomograph, figure VI-2, which has been devised to replace the graphics required by the visual method.

b. Yield Determination Procedure (GZ at Target Center).

(1) Determine the radius of target (R_T).

(2) Establish the R_D/R_T ratio required to achieve the fractional coverage (f) desired. This is read directly from the ADM fractional coverage nomograph (fig. VI-2) at the point where the fractional coverage curve of interest intercepts the R_D/R_T index.

(3) Calculate the radius of damage required; $R_D = R_T \times (\text{value of ratio})$.

(4) From the appropriate damage table, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Yield Determination Procedure (Displaced GZ). Except for entering the fractional coverage nomograph with the d/R_T ratio, the procedure follows that outlined in *b* above.

d. Illustrative Example (GZ at Target Center).

Given: Moderate damage to 40 percent of the railroad cars located in a railway marshaling yard is desired. The diameter of the target is 260 meters.

Find: The minimum surface burst ADM yield required to meet the above requirements.

Solution:

(1) $R_T = 260/2 = 130$ meters.

(2) From figure VI-2; For $f = .40$, $R_D/R_T = 0.62$.

(3) $R_D = 0.62(R_T) = 0.62(130) = 81$.

(4) From table II-1, R_D for the UNIFORM/.05 kt/ADM is 95 meters.

Answer: UNIFORM/.05kt/ADM

e. Illustrative Example (Displaced GZ).

Given: In the above problem, limiting requirements have caused ground zero to be displaced 100 meters from target center.

Find: The minimum ADM yield required to meet the 40 percent coverage requirements as stated previously.

Solution:

(1) $R_T = 130$ meters, $d = 100$ meters.

(2) Enter figure VI-2 with $d/R_T = 100/130 = 0.77$. For $f = 0.40$, $R_D/R_T = 0.83$.

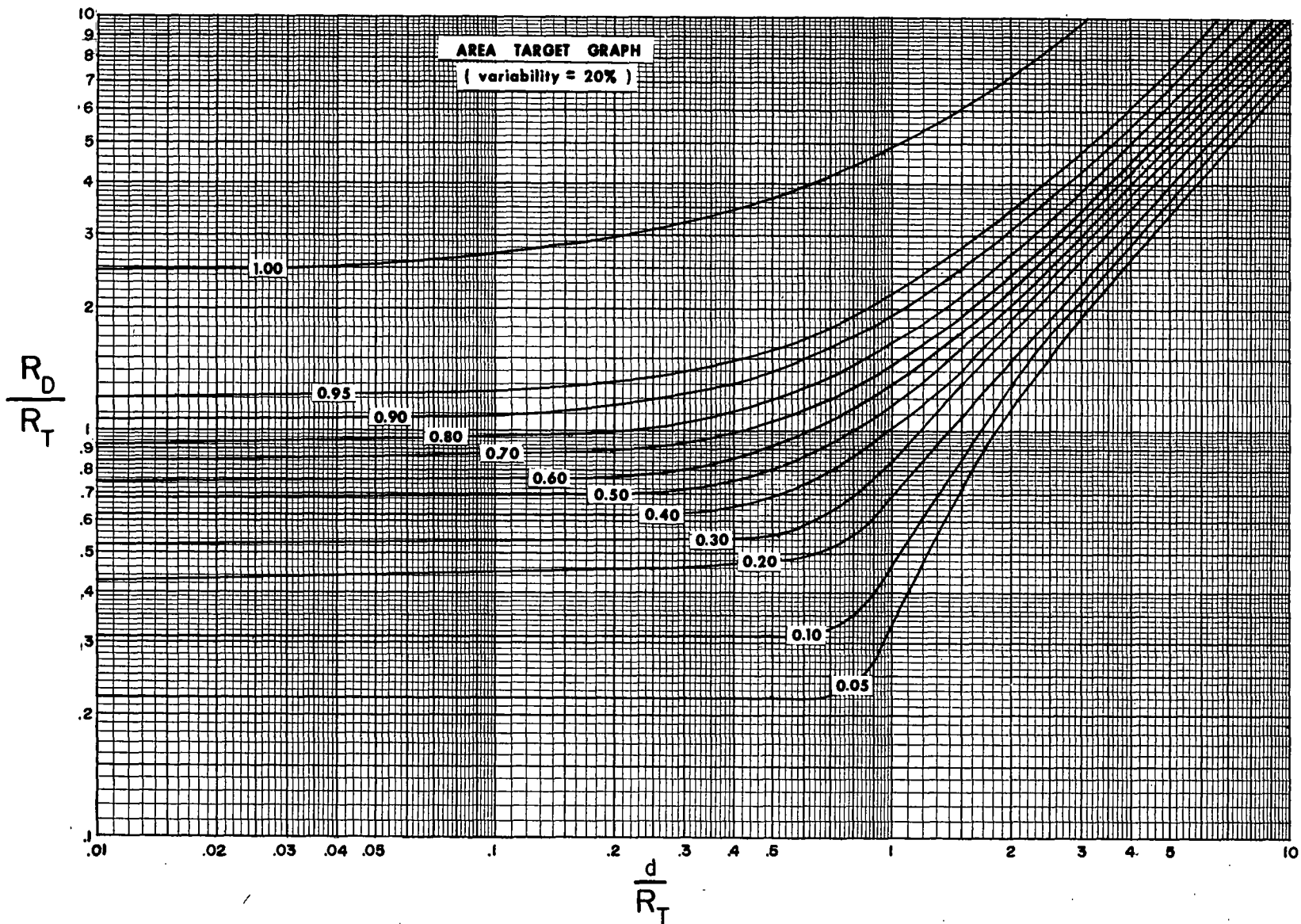
(3) $R_D = 0.83(R_T) = 0.83(130) = 108$.

(4) From table II-1, a VICTOR/.10kt/ADM has an R_D of 110 meters

Answer: VICTOR/.10kt/ADM

★A6-5. Preclusion of Damage

a. General. In many instances, the probability of not causing damage (Q) will be of interest to the target analyst. This is simply the reciprocal value of the probability of damaging the target. Preclusion of damage problems involve the use of the point target extension graph (fig. VI-1) for both point and area targets. In the latter case, the point of the periphery which is nearest ground zero is taken as being representative of the area target. In most instances, the probability will be specified



★Figure VI-2. ADM area target coverage nomograph.

and the separation distance (d) required between ground zero and the target calculated.

b. Procedure.

(1) Figure VI-1 indicates the probability of achieving a particular degree of damage; therefore, enter the graph with a value of $P = 100\% - Q$.

(2) Intercept the diagonal line and establish the d/R_D ratio.

(3) Determine the radius of damage (R_D) from appendix II.

(4) Calculate the minimum separation distance (d_{min}) required.

c. Illustrative Example.

Given: A very high assurance (99%) of not

causing moderate damage to a highway truss bridge in the vicinity of an ADM target is desired. The yield involved is a UNIFORM/.05 kt/ADM (surface burst).

Find: The separation distance (d) required to meet the above requirement. Assume that ground zero is located side-on to the bridge.

Solution:

(1) $P = 100\% - Q = 100\% - 99\% = 1.0\%$.

(2) Figure VI-1; $d/R_D = 1.49$.

(3) Table II-1, appendix II; $R_D = 90$ meters.

(4) $d = R_D (1.49) = (90) (1.49) = 134.1$ meters.

Answer: 134 meters.



APPENDIX VII

ILLUSTRATIVE EXAMPLES IN ADM TARGET ANALYSIS

A7-1. General

The examples used in this appendix illustrate the procedural steps outlined in paragraph 5-4 with regard to the detail analysis of ADM targets. These procedures are provided for guidance only since it is realized that the analyst will develop procedures of a more direct nature commensurate with his experience.

★A7-2. Illustrative Examples

a. Example Problem No. 1.

(1) *Given:* A rapid withdrawal of friendly troops which may necessitate the denial of prestocked military vehicles is being contemplated. The vehicles are uniformly distributed in the pre-stock site shown in figure VII-1. The area is approximately circular with a radius (R_T) equal to 150 meters. The commander desires severe damage to 75 percent of the target. In addition, the commander wants to preclude tree blowdown on Highway 50 as an obstacle to wheeled vehicles and to achieve a high assurance (90%) of not subjecting the village north of the target to an overpressure of 1 psi. The SOP specifies no more than a negligible risk to friendly troops. The closest friendly elements are 1500 meters south of target center, are in the RS-1 radiation service category, and are to be considered as warned and protected. Effective fallout winds are from the southwest. The allocation includes the following ADM:

- (a) ALFA/0.5kt/ADM.
- (b) BRAVO/1.0kt/ADM.
- (c) DELTA/5.0kt/ADM.

(2) *Find:* The most suitable ADM for this denial operation to include the location of ground zero and the fractional coverage to the target.

(3) Solution:

(a) *Step 1. Identify pertinent information.*

1. *Target information.* An area target ($R_T = 150m$) composed of military vehicles.

2. *Friendly forces.* Troops in the vicinity are warned and protected, 1500 meters southwest of target center. Negligible risk is not to be exceeded.

3. *Command guidance.* At least 75 percent coverage based on a severe level of damage is desired. Preclude tree blowdown on Highway 50, approximately 375 meters east of target center; provide at least a 90 percent assurance of not subjecting the village, situated 1600 meters north of target center, to 1 psi overpressure.

4. ADM allocation.

ALFA/0.5kt
BRAVO/1.0kt
DELTA/5.0kt

(b) *Step 2. Tentatively select point of detonation.* Initially, target center is selected as the ground zero location. A surface burst is planned in order to maximize the desired effect (airblast) and to facilitate emplacement. The resultant fallout does not affect tactical operations or the civilian population in the village in view of current wind conditions.

(c) *Step 3. Eliminate obviously unsuitable weapons.* The nature of this mission is such that none of the ADM allocated are eliminated at this time. Weight and size of the ADM do not pose any operational difficulty.

(d) Step 4. Determine data for—

1. *Estimating damage to the target* (table II-2). The numerical method is used although the visual method of damage estimation is also applicable.

	R_D	R_D/R_T	f (fig. VI-2)
ALFA/0.5kt	125m	0.83	70%
BRAVO/1.0kt	175m	1.17	94%
DELTA/5.0kt	325m	2.16	98%

2. *Troop safety* (table II-8). Since troops are in the RS-1 radiation service category, the warned-protected, negligible risk safety distances are as follows:

ALFA/0.5kt	1200m
BRAVO/1.0kt	1400m
DELTA/5.0kt	1700m

3. *Bonus effects and limiting requirements* (table II-6).

(a) *Tree blowdown distances* (type III forest).

ALFA/0.5kt	200m
BRAVO/1.0kt	300m
DELTA/5.0kt	600m

(b) *Extent of 1 psi overpressure.*

For a 90 percent probability of precluding 1 psi overpressure enter figure VI-1 with $P = 100\% - Q = 100\% - 90\% = 10\%$; $d/R_D = 1.26$. The required separation distance for each ADM in the allocation is listed below (table II-7):

	R_D	$1.26R_D$
ALFA/0.5kt	1050m	1323m
BRAVO/1.0kt	1325m	1670m
DELTA/5.0kt	2275m	2867m

(e) *Step 5. Eliminate unsuitable ADM.* The ALFA/0.5 kt is eliminated since it does not meet the coverage requirement ($f = 70\%$). The DELTA/5 kt is eliminated since it fails to meet the commander's requirement to preclude 1 psi overpressure to the village north of the target.

(f) *Step 6. Evaluation.* Only the BRAVO/1.0 kt is evaluated since all other ADM in the allocation have been eliminated. With this munition, displacement 70 meters south of target center is required to meet the 90 percent assurance specified for precluding 1 psi overpressure to the village. Displacing GZ 70 meters, coverage to the target is again computed—

$$\begin{aligned} R_D/R_T &= 175/150 = 1.17 \\ d/R_T &= 70/150 = 0.47 \\ f &= 80\% \end{aligned}$$

Fallout is not expected to offset the operation since friendly units are upwind of the fallout effective wind direction and outside the one cloud radius distance from GZ. By inspection, it is apparent that both troop safety and tree blowdown requirements are not affected by this displacement; therefore, further checks are not required.

(g) *Step 7. Make recommendations.*

1. Type and yield:
BRAVO/1.0kt/ADM
2. DOB:
Surface
3. GZ location:
70m south target center
4. Point of detonation:
N/A
5. Time of burst and option:
On order
6. Estimated results:
 $f = 80$ percent
7. Troop safety distance:
MSD (warned, protected; neg risk) 1400 meters

b. *Example Problem No. 2.*

(1) *Given:* It is planned to employ ADM to assist a covering force in delaying the enemy's advance from the north until arrival of the main body. Friendly mechanized forces have taken up delaying positions on the high ground as shown in figure VII-2 and are in the RS-1 radiation service category. The commander desires to use an ADM to crater the highway to include the width of clearing and to create tree blowdown as an obstacle to tracked vehicular movement in the adjacent type IVf forest for a distance of at least 200 meters. The width of clearing is 24 meters and is underlain with soft rock. Friendly troops will be warned, protected; further, the SOP specifies negligible risk. The fallout effective wind is from the south. The ADM allocation includes the following:

- (a) SIERRA/0.01kt/ADM.
- (b) VICTOR/0.10kt/ADM.
- (c) ALFA/0.50kt/ADM.

(2) *Find:* Minimum yield ADM that will meet the stated requirements.

(3) *Solution:*

(a) *Step 1. Identify pertinent information.*

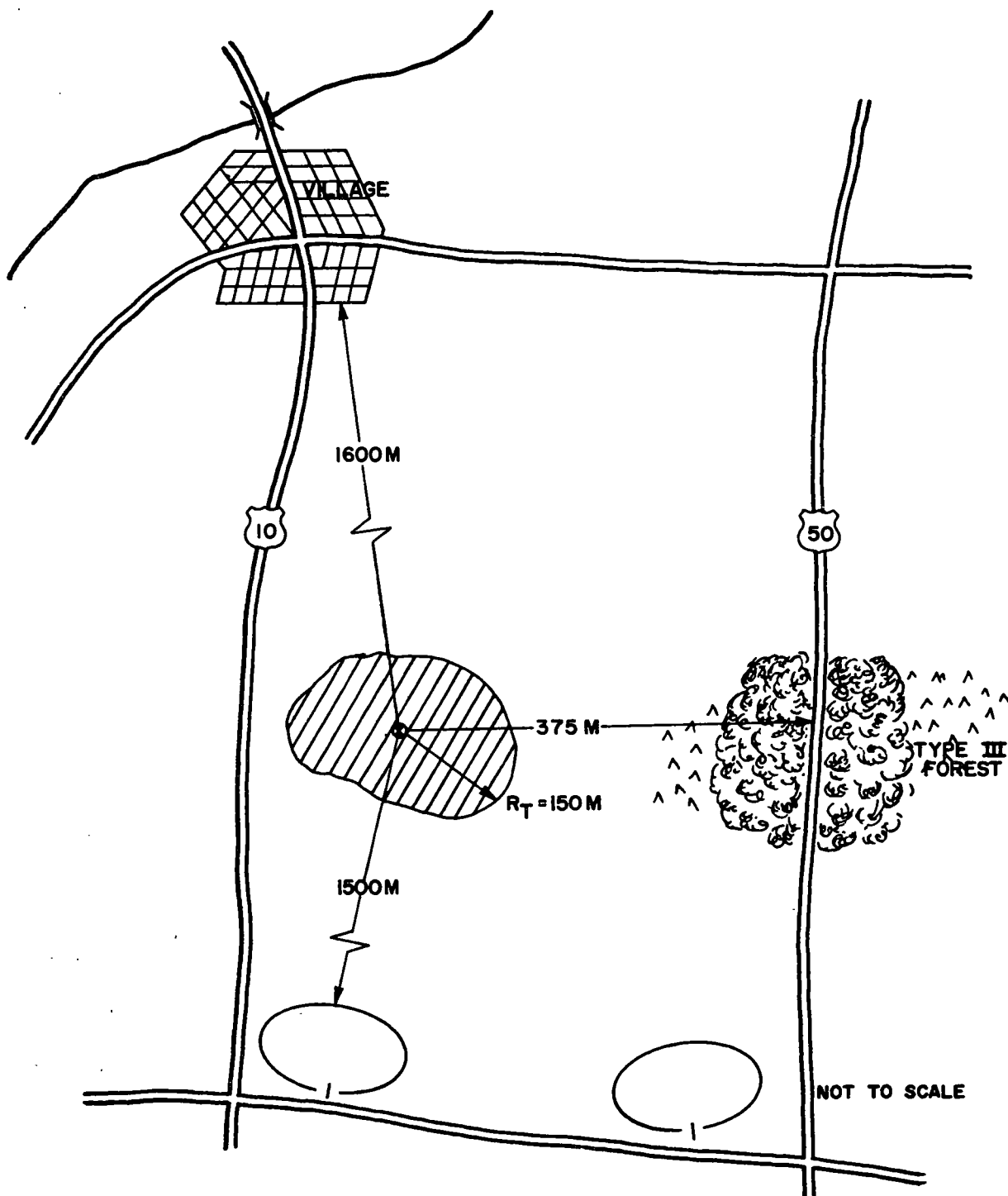


Figure VII-1. Sketch for example problem 1.

1. *Target information.*

D_A (required) = 24 meters. Radius of tree blowdown (required) = 200 meters.

2. *Friendly information.* The closest friendly troops are located 1400 meters from center of highway; these troops are warned and protected and negligible risk is specified.

(b) *Step 2. Tentatively select point of detonation.* The center of the highway is tentatively selected as the point of detonation. A surface burst (DOB = 0) is selected in view of the tree blowdown requirement.

(c) *Step 3. Eliminate obviously unsuitable ADM.* Weight or size limitations of available ADM impose no operational difficulty; therefore, none of the ADM are eliminated as obviously unsuitable.

(d) *Step 4. Determine data for—*

1. *Estimating damage to the target.*

In this case, a crater which covers the full width of clearing is desired. An examination of table II-3, Crater Dimensions, provides the following data:

	D_A	H_A
SIERRA/0.01 kt	9m	2m
VICTOR/0.10 kt	18m	4m
ALFA/0.50 kt	32m	6m

2. *Troop safety.* The distance from the tentative point of detonation to friendly lines is 1400 meters. Since troops are in the RS-1 radiation service category the troop safety distances are read direct from table II-8, for negligible risk to warned, protected troops. These distances are:

SIERRA/0.01 kt	900m
VICTOR/0.10 kt	1075m
ALFA/0.50 kt	1200m

3. *Bonus effects and limiting requirements.* Tree blowdown to prevent track vehicle movement extending at least 200 meters is required. Table II-6 indicates that tree blowdown (type IVf forest) extends to the following distances:

SIERRA/0.01 kt	75m
VICTOR/0.10 kt	135m
ALFA/0.50 kt	200m

(e) *Step 5. Eliminate unsuitable ADM.* Since the SIERRA/0.01 kt and the VICTOR/

0.10 kt do not provide a large enough crater, they are eliminated as unsuitable.

(f) *Step 6. EVALUATION.* There being only one ADM that meets the stated requirements, no further evaluation is made.

(g) *Step 7. Make recommendations.*

1. Type and yield:

ALFA/0.5 kt/ADM

2. DOB:

Surface burst

3. GZ location:

Center of highway as shown on

sketch

4. Point of detonation:

N/A

5. Time of burst and firing option:

On order

6. Estimated results

Crater (D_A = 32m and H_A = 6m) plus tree blowdown extending 200 meters from GZ

7. Troop safety:

MSD (warned, protected; negligible risk) 1200 meters

c. *Example Problem No. 3.*

(1) *Given:* The commander desires to use ADM against a railway marshaling yard as part of the denial operation. Target reconnaissance reports show the yard as being roughly circular in shape; there is a turntable, 25 meters in diameter, in the vicinity of target center; repair facilities, engine sheds, and rolling stock are uniformly distributed within an area 200 meters in diameter (R_T = 100m); the target site is underlain with dry soil; there are several buildings of historical importance 500 meters from target center; the area in the immediate vicinity is heavily populated. The following command guidance has been given: Destruction of the railway turntable and 75 percent coverage (moderate damage) to repair facilities, engine sheds, and rolling stock is desired. Friendly troop units will not be in the area; however, the local population (warned and exposed) is not to be subjected to more than a negligible risk criteria for military personnel in an RS-1 radiation service category. No more than light damage (1 psi overpressure) to the historical buildings is desired; if

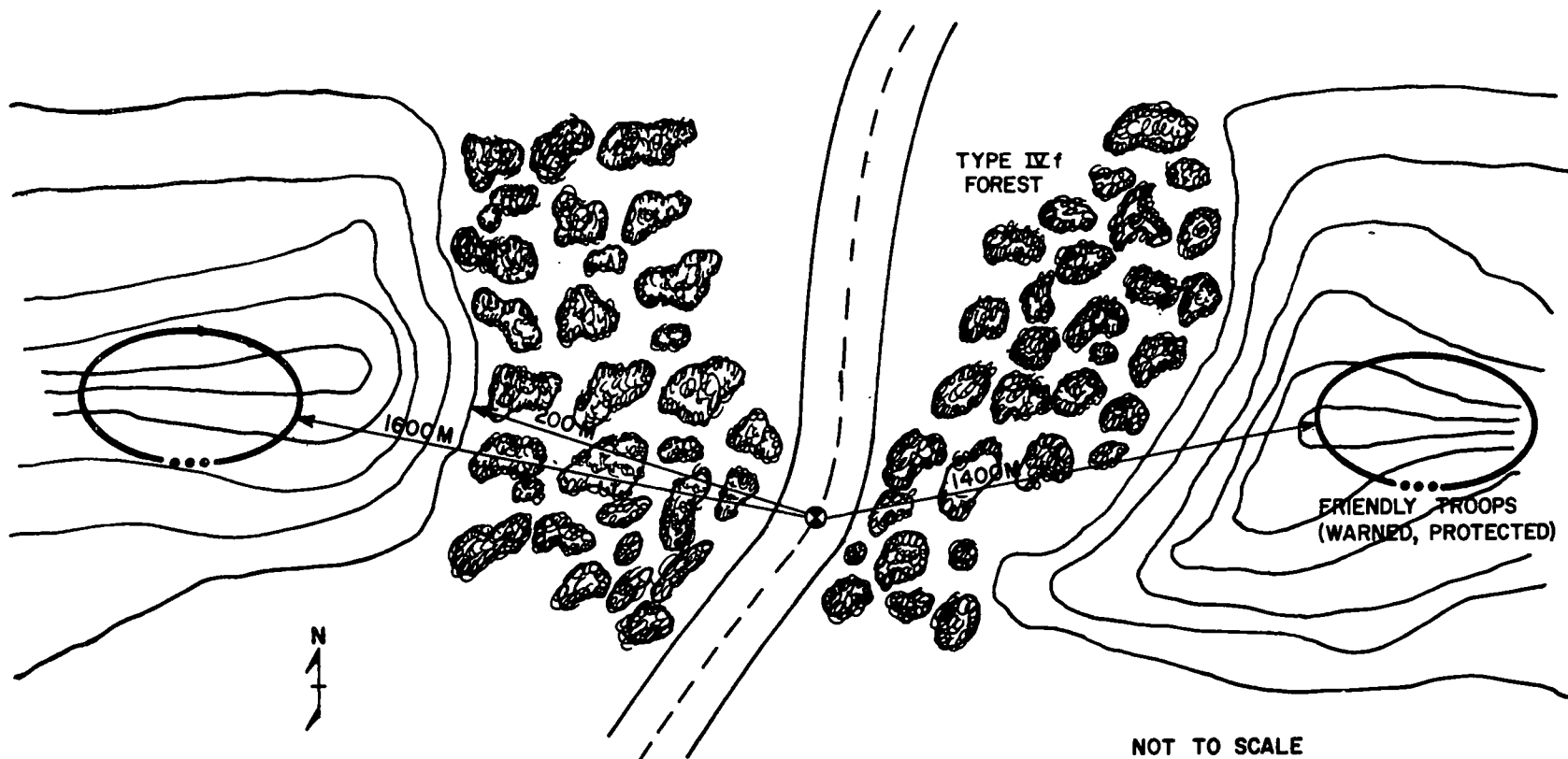


Figure VII-2. Sketch for example problem 2.

necessary, evaluation of local inhabitants to 2.0 kilometers from target center can be effected. The allocation includes one each of the following type ADM:

- (a) VICTOR/0.1 kt/ADM.
- (b) BRAVO/1.0 kt/ADM.
- (c) ECHO/10.0 kt/ADM.

(2) *Find*: The most suitable ADM, the location of ground zero, the DOB, the fractional coverage, and minimum safety distance for the local inhabitants.

(3) *Solution*:

(a) *Step 1. Identify pertinent information.*

1. *Target information.* The target consists of an area target ($R_T = 100m$) which is composed of engine sheds, repair facilities, and rolling stock and a railway turntable which is a point target. The area is underlain with dry soil. In accordance with the unit SOP for preplanned targets, an effective wind speed of 15 km/hr is used to evaluate the effect of fallout.

2. *Friendly forces.* Friendly troops will not be in the target area.

3. *Command guidance.* Destruction of the railway turntable and at least 75 percent (moderate damage) target coverage is desired; negligible risk to local inhabitants (warned and exposed) is not to be exceeded; and no more than light damage (1 psi overpressure) to historical buildings located 500 meters from target center is desired.

4. *ADM allocation.*

VICTOR/0.1 kt/ADM
BRAVO/1.0 kt/ADM
ECHO/10.0 kt/ADM

(b) *Step 2. Tentatively select point of detonation.* The turntable, in the vicinity of target center, is tentatively selected as the ground zero location. Because of the limiting requirements, a subsurface burst at optimum depth is tentatively planned to minimize the extent of initial nuclear radiation, fallout, and thermal radiation.

(c) *Step 3. Eliminate obviously unsuitable weapons.* Weight or size limitations of available ADM impose no operational difficulty; therefore, none are eliminated as obviously unsuitable.

(d) *Step 4. Determine data for:*

1. *Estimating damage to the target.*

(a) *Railway turntable.* Destruction of the railway turntable is assured if it is within the area defined by the apparent crater diameter. The minimum yield VICTOR/0.1 kt/ADM provides an apparent crater diameter of 53 meters at optimum depth, thus all other ADM in the allocation meet this requirement.

(b) *Engine sheds, repair facilities, and rolling stock.* Normally, airblast constitutes the governing effect against this type of target. At optimum depth, however, there will be a major reduction in airblast damage while cratering effects are maximized. Therefore, an estimate of damage to the above target elements based on the cratering mechanism is made. Using engineering judgment we assume the radius of moderate damage to be the distance to which the crater lip extends. Within this area, damage to the target elements results from the combined action of ground uplift and the ejection of the soil from the crater (ejecta). From figure 6-1, the crater lip is found to be twice the apparent radius ($R_L = 2 R_A$); therefore, in computing target coverage, the damage distance is equal to the radius of the crater lip (R_L). These values (see table II-3) are noted and the coverage from each of the ADM in the allocation is determined using the area target graph.

	DOB	R_L	R_L/R_T	f
VICTOR/0.1 kt/ADM ---	24m	53m	0.53	31%
BRAVO/1.0 kt/ADM ---	49m	107m	1.07	90%
ECHO/10.0 kt/ADM ----	97m	213m	2.13	99%

2. *Troop safety.* Troop units will not be in the target area at the time of detonation, however, the negligible risk MSD for warned and exposed personnel is determined (table II-8) for the benefit of the firing party and to assist in evaluating the hazard to the local inhabitants.

MSD*

- (a) VICTOR/0.1 kt/ADM ---- 1,300m
- (b) BRAVO/1.0 kt/ADM ---- 1,700m
- (c) ECHO/10.0 kt/ADM ----- 2,200m

*MSD are based on a surface burst. Reduction of safety distances for initial effects as a function of depth of burst cannot be quantitatively estimated at this time.

3. Limiting requirements.

(a) *Negligible risk to local population.*

(1) *Initial effects.* The MSD considering initial effects has been discussed in the above paragraph on troop safety.

(2) *Fallout.* The local population will be considered safe if located outside of the predicted zone II fallout area. The distance to which this zone extends is determined from table 7-2, based on a 15 knot effective wind speed.

	DOB	Zone II
VICTOR/0.1 kt/ADM	24m	0.57km
BRAVO/1.0 kt/ADM	49m	1.70km
ECHO/10.0 kt/ADM	97m	4.50km

(3) *Maximum missile range.*

The maximum missile range will not exceed the predicted Zone II fallout distance, but it may be significant upwind from the target. From figure 7-4 using a $DOB = 49m/k^{0.3}$, the maximum missile range (d_m) is found to be $820 (W)^{0.3}$ meters. The various values for the ADM in the allocation are as follows:

	$W^{0.3}$	d_m
VICTOR/0.1 kt/ADM	0.50	410m
BRAVO/1.0 kt/ADM	1.00	820m
ECHO/10.0 kt/ADM	1.99	1640m

(b) *Damage to historical buildings.* Using figure 7-1, the following probabilities (P) of producing damage at a range of 500 meters are obtained ($d = 500m$):

	DOB(m)	$H_n(m)$
VICTOR/0.1 kt/ADM	24	140
BRAVO/1.0 kt/ADM	49	280
ECHO/10.0 kt/ADM	97	557
	d/H_n	P%
VICTOR/0.1 kt/ADM	3.57	0.00
BRAVO/1.0 kt/ADM	1.78	0.00
ECHO/10.0 kt/ADM	0.89	71.0

(e) *Step 5. Eliminate unsuitable ADM.* The VICTOR/0.1 kt/ADM is eliminated since it does not meet the coverage requirement ($f = 31\%$). Also the ECHO/10.0 kt/ADM is eliminated because it does not meet the commander's guidance regarding the maximum missile range, the allowable overpressure to the historical buildings, and the acceptable limit of the predicted Zone II fallout distance.

(f) *Step 6. Evaluation.* Only the BRAVO/1.0 kt/ADM is considered acceptable since all other ADM in the allocation have been eliminated. With this munition placed at optimum depth of burial of 49 meters, all conditions for coverage and limiting requirements are met considering that local residents will be evacuated to a minimum distance of 2,000 meters. At this distance Zone II fallout will be avoided and the minimum safe distance will have small buffer zone included.

(g) *Step 7. Make recommendations.*

1. Type and yield:
BRAVO/1.0 kt/ADM
2. DOB:
49 meters
3. GZ location:
Target center
4. Point of detonation:
N/A
5. Time of burst and option:
On order
6. Estimated results:
Turntable destroyed plus 90 percent coverage
7. Safety distance:
(minimum distance to which civilians should be evacuated) 2,000 meters.



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★ APPENDIX VIII

**FRIENDLY NUCLEAR STRIKE WARNING TO ARMED FORCES
OPERATING ON LAND
(STANAG 2104 with Amendment No. 1)**

STANAG No. 2104
31 March/mars 1965

NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE L'ATLANTIQUE NORD
MILITARY AGENCY FOR STANDARDIZATION
BUREAU MILITAIRE DE STANDARDISATION

STANDARDIZATION AGREEMENT
ACCORD DE STANDARDISATION

SUBJECT
OBJET

FRIENDLY NUCLEAR STRIKE WARNING TO
ARMED FORCES OPERATING ON LAND
AVIS D'ATTAQUE NUCLEAIRE AMIE DES-
TINE AUX FORCES ARMEES EMPLOYEES
A TERRE

STANAG 2104

DETAILS OF AGREEMENT (DofA)
FRIENDLY NUCLEAR STRIKE WARNING TO ARMED
FORCES OPERATING ON LAND

AGREEMENT

1. It is agreed that the NATO Armed Forces will adopt the following system of friendly nuclear strike warnings for use at corps level and below. This applies to surface-to-surface and air-to-surface strikes in support of ground forces, and to emplaced atomic demolition munitions (ADM's).
GENERAL

2. The requirement for a standard warning message and delineation of notification channels is essential to ensure that timely warning of friendly nuclear strikes is provided so that Armed Forces personnel may take individual measures to protect themselves.

WARNING RESPONSIBILITIES

3. a. Responsibility for issuing the warning rests with the Executing Commander.
- b. Commanders authorized to release nuclear strikes will ensure that strikes affecting the safety of adjacent or other commands are co-

ordinated with those commands in sufficient time to permit dissemination of warnings to Armed Forces personnel and the taking of protective measures. Conflicts must be submitted to the next higher Commander for decision.

DETERMINATION OF HEADQUARTERS, FORMATIONS/UNITS TO BE WARNED

4. a. The Commander responsible for issuing the warning should inform:
 - (1) Subordinate Headquarters whose units are likely to be affected by the strike.
 - (2) Adjacent Headquarters whose units are likely to be affected by the strike.
 - (3) Own next higher Headquarters, when units not under the command of the releasing Commander are likely to be affected by the strike.
- b. Each Headquarters receiving a warning of nuclear attack will warn subordinate elements of the safety measures they should take, in the light of their proximity to the Desired Ground Zero (DGZ).
- c. Each unit concerned, down to the lowest level, will be warned by its next higher level of the safety measures it should take.

5. ZONES OF WARNING AND PROTECTION REQUIREMENTS FOR FRIENDLY NUCLEAR STRIKES

NOTES:

1. MSD means Minimum Safe Distance.
2. The MSD is equal to a radius of safety (R_s) for the yield, plus a buffer distance (d_b) related to the dispersion normal to the weapon system used and the orientation of friendly forces in relation to the line of fire. When surface bursts are used, the fallout hazard will be considered and appropriate buffer distances included.

<i>Radius</i>	<i>Correspondence to</i>	<i>Zone</i>	<i>Requirements</i>
DGZ			
		1	Evacuation of all Armed Forces personnel (See note 2).
MSD 1	Limit of negligible risk* to warned and protected Armed Forces personnel. (See note 3.)		
		2	Maximum protection. (See note 4.)
MSD 2	Limit of negligible risk* to warned and exposed Armed Forces personnel.		
		3	Minimum protection. (See note 5.)
MSD 3	Limit of negligible risk* to unwarned and exposed Armed Forces personnel.		
More than MSD 3	-----	-----	No protective measure except against dazzle.

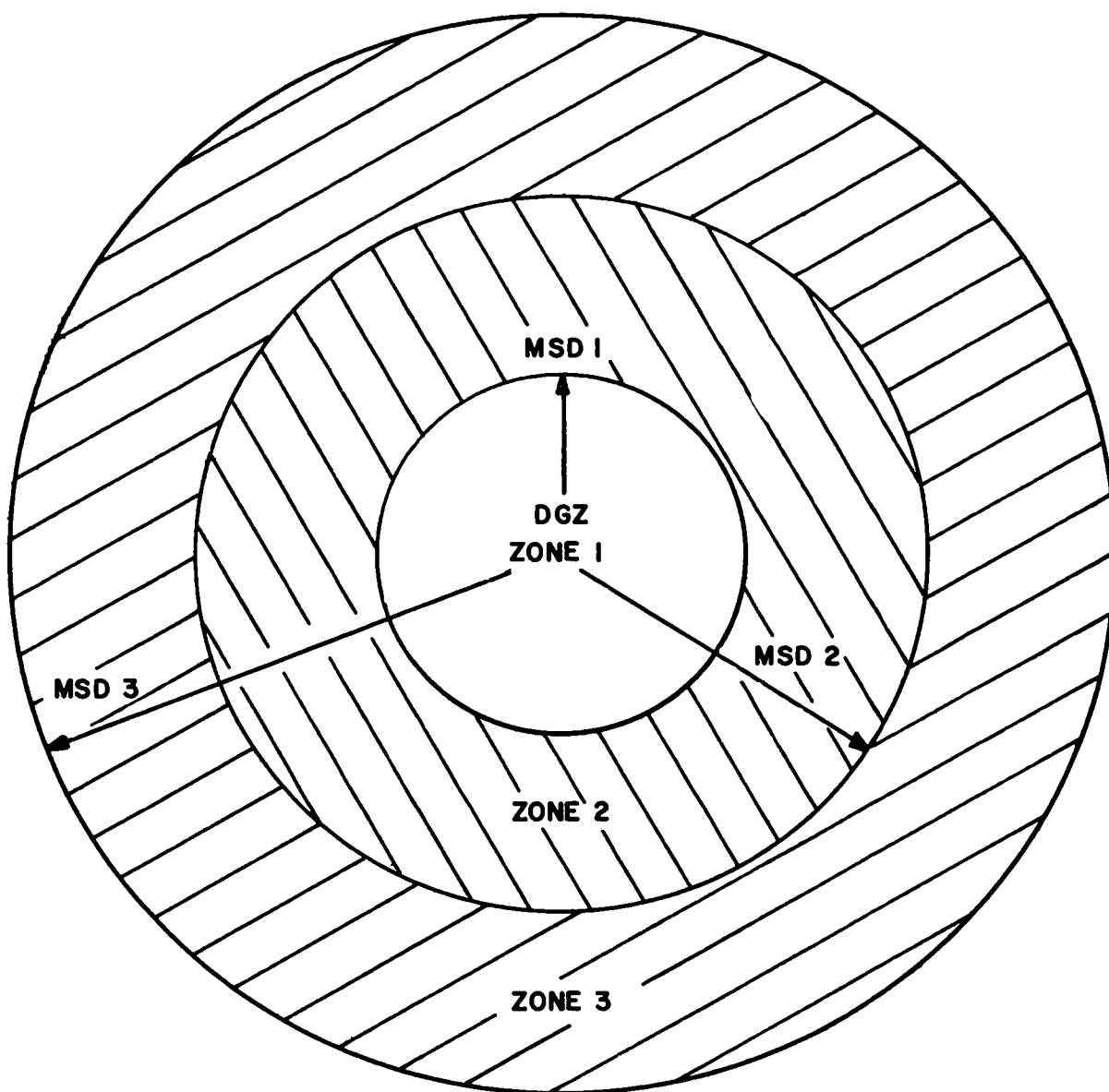


Figure VIII-1. Zones of warning and protection requirements for friendly nuclear strikes.

NOTES

1. Commanders will be guided by safety criteria as stated in FM 101-31-1, Staff Officers Field Manual, Nuclear Weapons Employment (or appropriate national manuals with the same criteria).
- * (as defined in STANAG 2083)
2. If evacuation is not possible or if a Commander elects a higher degree of risk, maximum protective measures will be required.

3. *Negligible risks should not normally be exceeded unless significant advantages will be gained.*
4. Maximum protection denotes that Armed Forces personnel are in "buttoned-up" tanks or crouched in foxholes with improvised overhead shielding.
5. Minimum protection denotes that Armed Forces personnel are prone on open ground with all skin areas covered and with an overall thermal protection at least equal to that provided by a two-layer uniform.

WARNING MESSAGES

6. Warning messages will include the following information (See STANAG 2103):

STRIKWARN

- ALPHA: Code word indicating nuclear strike (target number).
- DELTA: DATE/time group for time of burst in ZULU time.
The time after which the strike will be canceled (ZULU time).
- FOXTROT: DGZ (UTM grid co-ordinates).
- HOTEL: Indicate air or surface bursts.
- INDIA: For all bursts:
MSD 1 in hundreds of meters, four (4) digits
MSD 2 in hundreds of meters, four (4) digits
MSD 3 in hundreds of meters, four (4) digits
- YANKEE: For all bursts when there is less than a 99% assurance of no militarily significant fallout. Direction measured clockwise from grid north to the left and then to the right radial lines (degrees or mils—state which) four (4) digits each.
- ZULU: For all bursts when there is less than a 99% assurance of no militarily significant fallout. Effective wind speed in kilometers per hour, three (3) digits.
Downwind distance of Zone 1 (km), three (3) digits.
Cloud radius (km), two (2) digits.

EXAMPLE MESSAGES

1. FOR AIR BURSTS WITH 99% ASSURANCE OF NO MILITARILY SIGNIFICANT FALLOUT.
STRIKWARN. ALPHA TUBE SIX. DELTA PQ WM OT AR/AS DG WY OF.
FOXTROT YM AB IM SK. HOTEL AIR. INDIA 0022 0031 0045.
2. FOR ALL BURSTS WITH LESS THAN 99% ASSURANCE OF NO MILITARILY SIGNIFICANT FALLOUT.
STRIKEWARN. ALPHA TUBE SIX. DELTA PQ WM OT AR/AS DG WY OF.
FOXTROT YM AB IM SK. HOTEL SURFACE. INDIA 0022 0031 0045 YANKEE 0215 0255 DEGREES. ZULU 025 080 18.

IMPENDING STRIKE WARNING

7. Warning of impending strikes will be initiated no earlier than is necessary to complete warning of Armed Forces personnel. Any available means of communications—land lines if possible—will be utilized to ensure that all Armed Forces personnel requiring warning are notified.

ACTION ON CANCELLED STRIKES

8. When nuclear strikes are cancelled, units previously warned will be notified in the clear by the most expeditious means in the following format:

- a. Code Word (Target Number)
- b. CANCELLED

USE OF CODES

9. Items DELTA and FOXTROT above will not be sent in clear unless the time of initiating the warning message is such that no loss of security is involved.

10. Only coding systems which meet NATO security criteria will be used.

OTHER WARNINGS

11. It is recognized that it is impractical to obtain warnings of surface-to-air (for instance, air defense) nuclear bursts which may occur at low altitudes, and to disseminate such warnings to Armed Forces personnel.

12. Similarly, it may be impractical to provide warning to the Naval and Air Forces concerned of intended surface-to-surface strikes delivered by weapons within the corps, especially for fleeting targets or when reaction times are short. Nevertheless, it is the responsibility of Army agencies to provide warning to Naval and Air Forces concerned whenever possible.

IMPLEMENTATION OF THE AGREEMENT

13. This STANAG will be considered to have been implemented when the necessary orders/instructions putting the procedures detailed in this Agreement into effect have been issued to the forces concerned.



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USACDCQMA (1)
USACDCMSA (4)
USACDCMPA (1)
USACDCOA (2)
USACDCSWA (2)
USACDCCEA (5)
USACDCEA (25)
USACDCIAS (1)
USACDCEC (5)
USACDCCNG (5)
USACDCCCISG (1)
USACDCCAA (1)
MAAG (2)
Mil Msn (2)

NG: State AG (3); Div (5); TOE 5-146 (3); 5-156 (3).

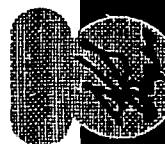
USAR: Units—same as active Army except allowance is one copy each unit.

For explanation of abbreviations used, see AR 320-50.



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CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual provides guidance for tactical commanders and staff officers in the operational and logistical aspects of atomic demolition munitions (ADM) employment. In addition, ADM target analysis techniques and emplacement methods are discussed for engineer personnel and nuclear weapons employment officers.

1-2. Scope and Organization

a. The doctrine presented in this manual is primarily concerned with ADM employment within the field army area (combat zone).

b. This manual presents only that material which is applicable to ADM employment and emplacement for surface or subsurface bursts.

c. Complete coverage of ADM employment, operational concepts, and target analysis is provided in two separate field manuals:

(1) This manual provides doctrine concerning those unclassified facets of ADM operations applicable to active nuclear warfare. It contains U. S. Army concepts for ADM employment, and the command and staff actions required to carry out those concepts. In addition, detailed procedures regarding ADM target analysis techniques are presented in this text as well as methods of ADM emplacement. This text presents data concerning a family of hypothetical atomic demolition munitions designed specifically for use in unclassified ADM instruction. Illustrative problems in target analysis employ unclassified data extracted from these hypothetical effects tables.

(2) Classified defense information concerning ADM currently within the United States stockpile is included in FM 101-31-2. It provides tabular

data necessary for target analysis and presents items of information concerning technical procedures which are not a part of this manual because of security classification. This manual is also designed for active nuclear combat.

(3) The organization of the ADM effects tables in both texts is similar. Differences in data between United States stockpile ADM and the family of hypothetical ADM are intentional in order to protect the security of actual ADM. Proficiency in the use of hypothetical effects tables, however, insures facility in the use of the actual effects tables.

d. This manual repeats information presented in other military publications only as required for clarity or consistency. Consequently, this manual should be used in conjunction with other applicable military publications (see app. I).

1-3. Changes

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commanding Officer, U. S. Army Combat Developments Command Engineer Agency, Fort Belvoir, Va. 22060.

1-4. Concepts of ADM Employment

The doctrine in this manual is based on the following national policy and concepts:

a. The U. S. Army is organized and equipped to fight in nuclear and in nonnuclear war or under the threat of nuclear warfare.

b. ADM are employed within the theater of operations in accordance with national policy and when their use is authorized by the theater commander.

c. Once the use of ADM has been authorized, responsibility for ADM employment is normally decentralized to the lowest tactical echelon capable of conducting ADM mission planning, coordination, and execution.

d. ADM are employed against materiel targets rather than personnel thus constituting an addition to the present family of military explosives. Their use parallels or complements those of conventional demolitions. Employment of ADM rather than conventional explosives is usually dictated by the resultant savings in time, manpower, and logistical effort.

e. ADM are employed in conformance with tactical requirements to deter the enemy and deny the use of key structures and installations such as dams, bridges, and industrial facilities. Lowest possible yields consistent with military and political necessity are employed to prevent civilian casualties, over-destruction of manmade and natural features, or unacceptable radiation hazards.

f. A commander employing ADM coordi-

nates with unit commanders in whose area militarily significant nuclear effects are expected to extend. Lacking concurrence, authorization to employ the demolition is requested from the commander who exercises military control over both affected areas.

g. ADM are closely related to the family of nuclear weapons because of their nuclear characteristics and consequent massive destructive potential. In this regard, ADM are subjected in large measure to the same command and control procedures developed for nuclear weapons; i.e., mission planning, security, logistics, troop safety, target analysis, and authority to fire.

1-5. System of Measurement

In accordance with AR 525-8, tabular data for nuclear blast, thermal, and radiation effects, minimum safe distances, and related contingency effects are expressed in the metric system of measurement. However, to facilitate target analysis procedures, cratering data applicable to the demolition of structures and creation of terrain obstacles are expressed in both the English and metric measurement systems. Appendix V contains tabular data to assist in converting from one measurement system to the other when the need arises.

c. *Firing Options.* Once emplaced, each ADM of the hypothetical family is considered to have a remote, on-call firing capability as well as a timer option. When using timer option, the time of detonation may be varied in 10-minute increments from 10 minutes to 1 hour and in 30-minute increments to 12 hours. Accuracy of the timer is assumed to be ± 5 minutes per hour of time set on the timer (para 4-12).

d. *Subsurface Capability.* ADM of the hypothetical family are assumed to have both an underground and underwater capability. Underground burial is limited to 10 meters (33 ft) of backfill which is tamped material replaced directly on top with no protective shielding of the ADM. Underwater detonation is possible in depths up to 30 meters (100 ft). If greater depths are desired, special adaptive devices are required to protect the munition from excessive overhead pressure.

e. *Separation Distance.* To insure that one emplaced ADM is not damaged by the detonation of another in the same general target area, it is assumed for the hypothetical family that a separation distance of 1,000 meters (3,300 feet) between ADM detonations on the surface is required for all yields. For subsurface bursts near optimum depths, this distance may be reduced by one-half.

f. *Residual Radiation.* Residual radiation is an important consideration in the employment

of ADM. This aspect of ADM employment from a troop safety standpoint is discussed in chapter 7.

3-6. Response Time

In addition to the design characteristics of ADM, the time necessary to analyze the target, secure the emplacement site, deliver and prepare the ADM for firing, emplace the munition, and warn friendly units significantly affects the manner in which ADM are employed. As a basis for general tactical planning, 2 hours is assumed to be the average time for a reasonably well-trained ADM team operating in daylight under favorable conditions to prepare and emplace a hypothetical ADM with remote options on the surface or in a previously prepared position. If only timer option is used, planning time may be reduced to 1 hour. Blackout operations, enemy interference, elaborate emplacement techniques, or severe weather conditions may considerably extend this period. Moreover, transportation time to the emplacement site is in addition to the above stated times. Obviously, each target presents varied circumstances which affect response time and require individual consideration prior to ADM employment. Nevertheless, response time may be materially reduced by thorough training and the establishment of effective ADM standing operating procedures (SOP).

Section II. COMMAND AND STAFF PROCEDURES

3-7. General

Planning for the employment of ADM involves the same command and staff procedures normal to planning any tactical operation. The command, intelligence, operational, and logistical procedures are carried out concurrently rather than sequentially. ADM missions are implemented by plans and orders formulated under the guidance of the tactical commander during staff planning.

3-8. Allocation of ADM

a. Because of the combat potential afforded by ADM and their limited number, the com-

mander carefully controls the supply, expenditure, and resupply of this type munition. ADM fall into the category of special ammunition, which is ammunition specially designated by the Department of Army because of unique requirements in control, handling, and security.

★ b. An allocation of ADM is the apportionment of a specific number of complete ADM to a commander during a specified period of time as a planning factor for use in the development of plans. Additional authority is required for actual dispersal of allocated ADM to locations desired by the commander to

support his plans. A commander cannot authorize the expenditure of an ADM unless he has a release by proper, competent authority. This release is termed assignment. Procedures for disposition of excess ADM are found in FM 9-6.

c. The duration of the allocation periods are generally dictated by the commander's concept of the operation. He allocates ADM for the period during which he can visualize the operation. He retains ADM in reserve for those periods that he cannot visualize, i.e., for employment against targets of opportunity and for use during later phases of the allocation period. The duration of an allocation period differs at each echelon of command. The field army commander may be allocated ADM for a longer period than the corps commander and the corps commander for a longer period than the division commander.

d. Reserve maneuver forces receive only a planning allocation until committed; at this time, they may be assigned a portion of the reserve allocation.

e. A commander who allocates ADM to a subordinate command may withdraw or change that allocation as required. Reduction in an allocation is made only when absolutely essential and with as much prior notification as possible.

3-9. Command Guidance

a. The magnitude and nature of nuclear effects have a profound influence on ground operations. Therefore, command guidance to the staff before commencement of planning is essential. If there is little time for staff planning, this guidance may consist of an immediate decision by the commander to employ ADM. When more time is available, the guidance may include specific courses of action for staff consideration during the development of staff estimates.

b. In developing his initial staff planning guidance, the commander considers the requirements of all the general staff. In addition, he provides guidance for the staff en-

gineer, the artillery commander, the chemical officer, and other concerned staff officers. The commander provides additional guidance as required throughout all planning phases up until the time the ADM mission is executed.

c. It is essential that commanders and staff officers generally understand the capabilities and limitations of ADM, the combat service support requirements involved, and the procedures for employing these munitions. These officers receive technical advice from nuclear weapons employment officers (NWEEO) and engineers on matters relating to the use of ADM.

d. Initial staff planning guidance normally falls into the following categories: type of targets, allocation to subordinate units, desired ADM reserve, and acceptable degree of risk for civilian populations in the area. The commander's initial staff planning guidance for ADM employment varies in content with the echelon of command. Damage criteria and troop safety considerations are matters of standing operating procedures (SOP). Command guidance in these respects is appropriate only when departure from SOP is desired. Based on the SOP, the nuclear weapons employment officer and engineer determine the extent and nature of the damage desired and recommends the ADM best suited for that task. Similarly, the commander designates, whenever possible, negligible risk for his own and adjacent forces. The staff, without further direction, takes this into account in their operational planning. If greater than negligible risk must be taken or if friendly troops must be warned, the nuclear weapons employment officer includes this information as part of his recommendations. Creation of obstacles to friendly movement and similar undesirable effects are also matters of SOP not normally requiring specific guidance to the staff and nuclear weapons employment officers.

3-10. Staff Responsibilities

a. In planning the employment of ADM, certain specific responsibilities are allocated to the general and special staff. Coordination

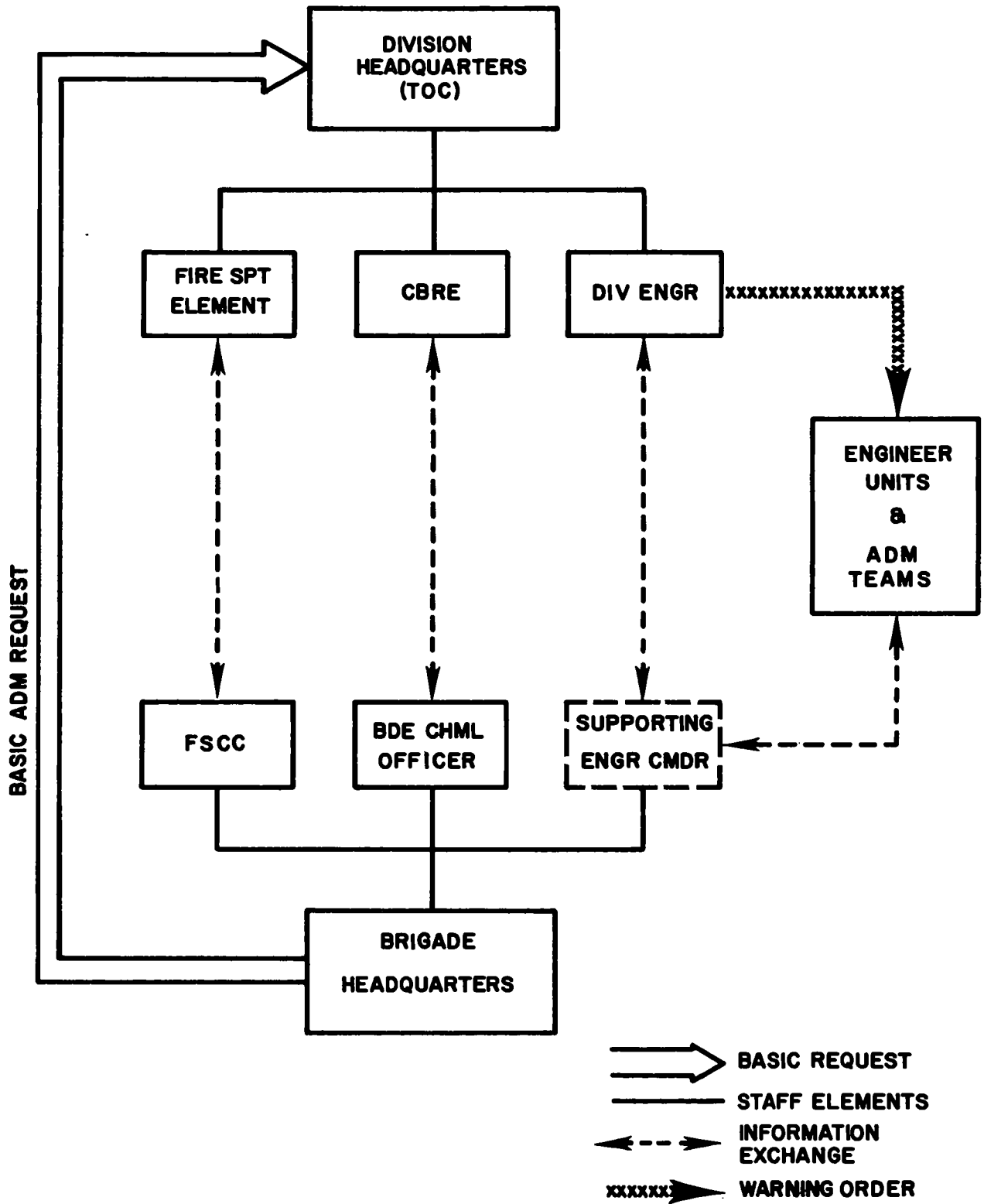


Figure 3-4. Typical ADM requests from bridgade to division.

3-17. Preplanned Targets

Normally, preplanned, *tactical demolition targets* are planned and executed on order of corps and lower commanders. *Strategic demolitions*, on the other hand, may be planned and executed on order of field army or higher command echelons. If a demolition target has both strategic and tactical implications, preparation and execution of the target is usually delegated to the tactical commander responsible for the area in which the target is located. Some targets may be so important to the success of the operation, however, that the commander authorizing ADM employment may retain target execution for his own order. Such demolition targets are termed *reserved demolitions* (FM 31-10) and may include targets planned as part of preliminary operations as well as those to be destroyed in the face of an advancing enemy. For reserved demolitions, the commander in control of target execution establishes direct communications with the commanders concerned or dispatches a liaison agent or staff officer to the target site to receive and transmit the execution order. Under such circumstances, the liaison agent insures that destruction is accomplished at the proper time through coordination with responsible commanders in the target area. Regardless of the method of execution, at least three commanders are normally concerned with the execution of preplanned demolitions—

a. *The releasing commander* (authorized commander) has overall responsibility for the mission, authorizes the ADM to be employed from his own nuclear allocation or requests an additional allocation from higher command echelons, and orders or delegates target execution. The releasing commander may utilize his own headquarters or designate a subordinate *executing unit* to conduct the ADM mission (para 3-18).

b. *The demolition guard commander* is normally a subordinate of the executing unit commander and is held responsible for his assigned ADM target and the local security thereof (para 3-19).

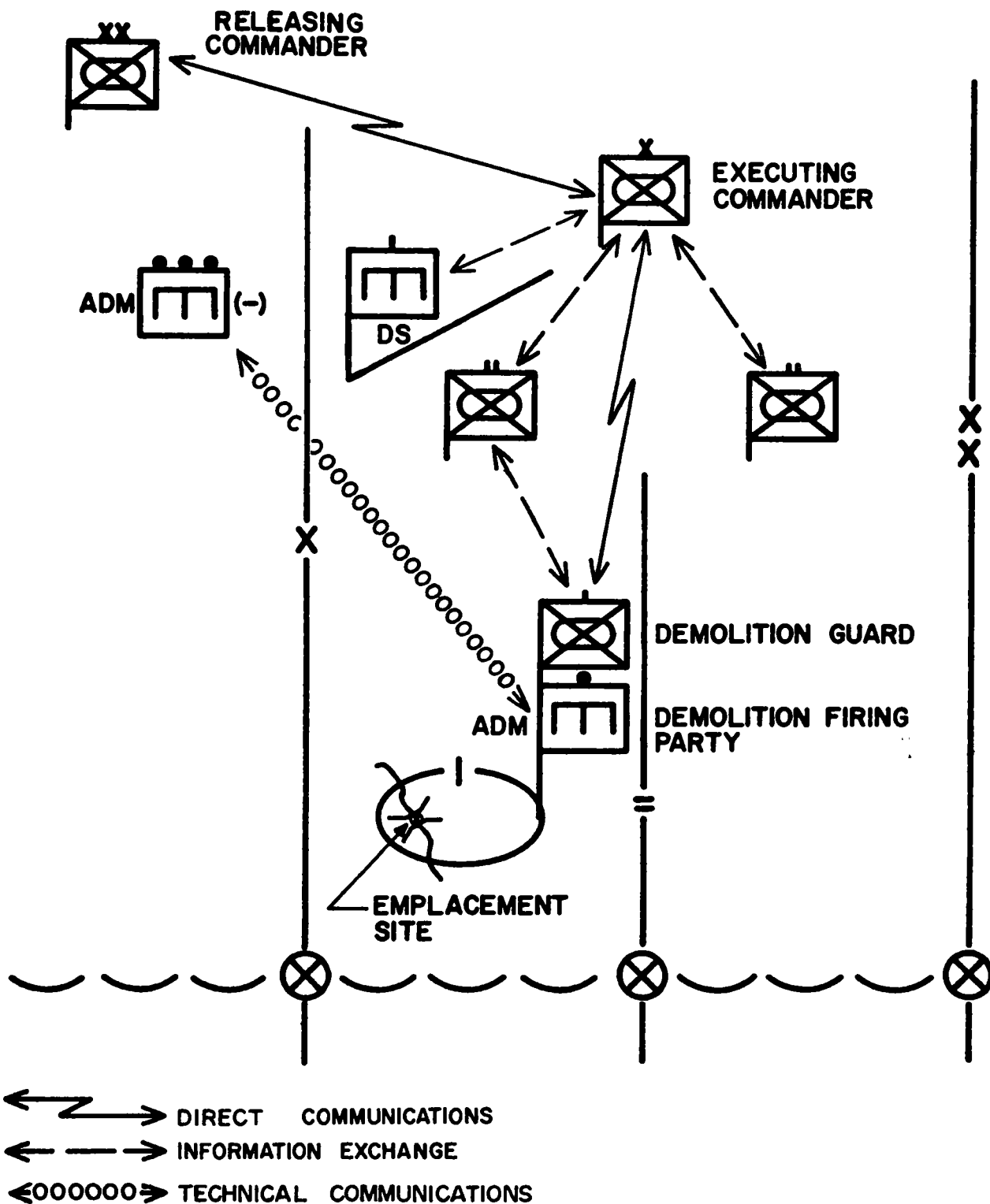
c. *The demolition firing party commander* is the senior engineer of the ADM firing party attached to the demolition guard for the mission (para 3-20).

3-18. Releasing Commander

a. The releasing commander is normally the commander of a division or larger formation. He is appointed by higher headquarters and is empowered to authorize ADM expenditure subject to the restraints imposed by higher authority. The releasing commander exercises approval authority over all subordinate ADM plans and targets within his operational area. He designates his own headquarters or a subordinate unit as the executing headquarters for each ADM mission. A combat maneuver brigade, a task force, or any other major unit tactically responsible for the target area may act as an executing unit. In areas not under the control of a subordinate tactical commander, the releasing commander may resignate an engineer group or battalion commander as the executing commander.

b. The releasing commander provides the executing unit with the resources needed to accomplish the mission. He provides instructions, as required, to coordinate all elements engaged in the mission and insures that adequate control procedures are initiated. If authority to detonate the ADM is retained by the releasing commander, reliable channels of communication must be established whereby the order to detonate the ADM may be quickly and securely transmitted.

c. The executing commander is responsible for ADM targets within his operational area and the execution of such targets in accordance with the orders of the releasing commander. The executing commander informs the releasing commander of any ADM mission beyond his capability and, if appropriate, recommends alternate courses of action. Details of the mission not specified by the releasing commander, such as fire support coordination, are the responsibility of the executing unit. The executing commander usually designates the formation (the demolition



★ Figure 3-5. Communications for a typical ADM target.

☆3-20. Demolition Firing Party
Commander

a. The demolition firing party is the element responsible for the technical aspects of the ADM mission. Its members are drawn from the appropriate engineer ADM unit (para 4-13-4-15).

b. The demolition firing party commander normally will be an engineer ADM squad leader. He is directly responsible to the demolition guard commander for the proper execu-

tion of the mission in accordance with the Atomic Demolition Firing Order (DA Form 3065-R) (app IV). In addition, he furnishes the demolition guard commander with technical advice on transportation requirements, prefire test procedures, firing procedures, safing procedures, factors affecting reliability of the munition, emergency denial, and technical requirements for the emplacement site and command site.

Section IV. WARNING, LOGISTICAL, SECURITY, AND

SAFETY PROCEDURES

3-21. Warning of Friendly ADM Detonations

a. Advance warning of ADM detonations is required to insure that friendly forces and civilians are not subjected to casualty-producing nuclear effects. When an ADM is preplanned, there is usually adequate time to alert personnel in areas where significant effects may be received. On the other hand, when ADM are employed against targets of opportunity, a standing operating procedure is required which permits rapid notification of personnel who could be affected by the detonation. The difficulty of warning all personnel can be appreciated if the various concurrent activities in the combat zone are visualized. Messengers, wire crews, litterbearers, aid men, and engineer work parties move about frequently in the performance of their duties and often are not in the immediate vicinity of troop units when warning of impending nuclear employment is issued.

(1) Notification concerning friendly nuclear employment is a time-consuming process unless procedures are carefully established and rehearsed. On the other hand, dissemination of warning earlier than necessary may permit the enemy to learn of the operational plan.

(2) When there is insufficient time to warn personnel within the limit of visibility, only those who may receive

tactically significant nuclear effects are warned. Generally, there is no requirement to warn subordinate units when target analysis indicates that there is no more than a negligible risk to unwarned, exposed troops. Dazzle to ground troops need only be considered in night operations.

(3) Aircraft, particularly Army aircraft, can be damaged by low blast overpressures. Likewise, dazzle is more significant to personnel operating aircraft than to personnel on the ground. Because aircraft can move rapidly from an area of negligible risk to an area where damaging nuclear effects or dazzle may be encountered, all aircraft within the area of operations are given advance warning.

(a) Army aircraft are warned through the appropriate air traffic control facility or through the unit command net.

(b) Navy and Air Force aircraft are warned through Navy and Air Force channels. At corps and division level, the notification of planned nuclear employment is transmitted to other services through the Navy or Air Force liaison officer; at field army level,

this notification is accomplished through the Air Support Operations Center (ASOC).

- (4) When employing very low yield nuclear detonations against targets of opportunity, some relaxation of the requirement for positive warning may be authorized.

b. Nuclear employment warning messages are disseminated as rapidly as possible. The requirement for speed is frequently in conflict with a requirement for communication security. Authentication procedures and encoding instructions for nuclear strike warning messages are included in unit signal operations instruction (SOI).

- (1) The amount of information to be encoded is held to a minimum in order to expedite dissemination.

- (2) Message items DELTA and FOX-TROT (app VIII) will not be sent in the clear unless insufficient time remains for the enemy to react.

c. Nuclear warning messages are given a precedence of FLASH.

d. The zones of warning, protection requirements for personnel located in any of the warning zones, and the content of a nuclear warning message (STRIKWARN) are prescribed by STANAG 2104 which is reproduced in appendix VIII.

e. All available communication means are used to rapidly disseminate nuclear warnings.

f. A fragmentary warning order may be issued while an ADM mission is being processed to alert units that are in an area where they may receive nuclear effects.

g. Procedure for friendly nuclear detonation warning.

- (1) Warning responsibilities.

- (a) Responsibility for issuing the initial warning rests with the commander requesting the nuclear detonation.

- (b) Commanders authorized to release nuclear detonations will insure that detonations affecting the safety of adjacent and other commands are coordinated with those commands in sufficient time to permit dissemination of warnings to friendly personnel and the taking of protective measures. Conflicts must be submitted to the next higher commander for decision.

nation of warnings to friendly personnel and the taking of protective measures. Conflicts must be submitted to the next higher commander for decision.

- (2) The commander responsible for issuing the warning should inform—

- (a) Subordinate headquarters whose units are likely to be affected by the detonation.

- (b) Adjacent headquarters whose units are likely to be affected by the detonation.

- (c) Own next higher headquarters, when units not under the releasing commander are likely to be affected by the detonation.

- (3) Each headquarters receiving a nuclear warning message will warn subordinate elements of the safety measures they should take in light of their proximity to the DGZ.

- (4) Unit SOP should require that STRIKWARN messages be acknowledged and there should be common understanding as to the meaning of the acknowledgment; e.g., all platoon-size units in the affected area have been warned.

3-22. Distribution of Atomic Demolition Munitions

a. Commanders and staff officers continuously evaluate the capabilities and limitations of logistical systems to support nuclear employment. Because of the destructive nature and limited availability of nuclear munitions, distribution is an operational as well as a logistical problem.

b. The nuclear munition logistical system is designed to operate in different tactical situations, forms of warfare, and operational environments. Commanders and staff officers concerned with planning and controlling special ammunition support activities consider the following requirements:

- (1) Continuous nuclear logistical support of tactical operations.

- (2) Simplicity and uniformity in procedures.

(3) Minimum handling of nuclear ammunition.

(4) Security of classified or critical material and installations.

☆ c. The specific quantity of special ammunition to be carried by a delivery unit is termed the prescribed nuclear load (PNL). The specific quantity of various special ammunition items to be stocked in an ordnance unit or installation is termed prescribed nuclear stockage (PNS).

☆ d. A commander controls the distribution of ADM by—

(1) Determining the number of ADM which organic or attached units under his control will carry as part of their SAL.

(2) Designating any ADM from his own allocation or the allocation of a higher commander which he desires to have carried in the SAL of a unit that is under the control of a subordinate commander. This SAL may contain ADM to support the allocation of the subordinate commander as well as those to be delivered to support the allocation of the higher or adjacent echelon.

(3) Coordinating the stockage of ADM as part of the SAS of a special ammunition installation not under his control; directing the ADM stockage in special ammunition installations under his control.

e. The positioning of ADM for security and operational purposes may result in a commander having more ADM carried by his emplacement units than he is authorized to fire. He may also have fewer ADM within his command than he has been allocated. In the latter case, procedures are established by which the additional ADM can be quickly obtained when required.

f. When the availability of ADM permits, consideration is given to placing them in all engineer emplacement units. ADM may be so

dispersed before allocations are announced. In some cases, this procedure permits greater responsiveness once unit allocations are announced.

☆ g. Replenishment of SAL and SAS is accomplished by directed issue, automatic issue, or a combination of both. Because of the limited supply and the movement of ADM to meet the changing tactical situation, directed issue is most practical. If a relatively large number of ADM of a specific type and yield is available, a commander may direct that engineer units under his control replenish their SAL automatically as expenditures occur. The method of replenishment should be covered in the SOP.

☆ h. Distribution of ADM is affected by—

(1) Mission.

(2) Allocation and assignment.

(3) Munition availability.

(4) Carrying capacity of emplacement units.

(5) Security.

(6) Transportation capability of support units.

i. Nuclear munitions are stored and issued to ADM teams by special ammunition units. Issues are made using supply point distribution procedures. The details of ammunition service are contained in FM 9-6.

☆3-23. Tactical Accountability

The decisive character of nuclear weapons and their limited availability make detailed accounting necessary. Information pertaining to ADM location, allocation, assignment and expenditure is made available to the members of the TOC, the artillery fire direction center, and the staff engineer. In addition, the TOC and the engineer need information on ADM readiness status, operational capabilities of engineer emplacement units, and the travel time between logistical and tactical locations. This information is maintained in a manner to permit ready display to the commander and staff officer. Suggested forms or methods by

CHAPTER 4

COMBAT ENGINEER UNITS

Section I. ENGINEER STAFF RESPONSIBILITIES

4-1. General

The field army, corps, and division engineer staff officers rely heavily on their staffs in the preparation, planning, and conduct of ADM missions. Normally, the staff engineer delegates to members of his unit staff responsibility in the preparation, planning, and conduct of ADM missions. Key personnel of engineer brigades, combat groups, and combat battalions charged with primary staff responsibility in ADM operations are the intelligence officer (S2), the operations officer (S3), and the supply officer (S4). Other staff officers such as the assistant division engineer, adjutant (S1), reconnaissance officer, liaison officer, and communications officer perform duties in ADM operations as specifically directed by the unit commander or as outlined in the unit SOP. Moreover, each subordinate engineer commander assumes an engineer staff role when in direct support of or attached to a combat maneuver element and is, in such circumstances, also responsible for advising the supported commander in engineering aspects of ADM employment.

4-2. Intelligence Officer (S2)

Responsibilities normally assigned to the engineer S2 in ADM employment include—

a. The collection and evaluation of potential ADM targets to include structural, geologic, and cultural characteristics (paras 4-5 and 4-6).

b. Terrain and weather analyses pertinent to ADM targeting.

c. Ground and aerial reconnaissance of selected ADM targets (para 4-6).

d. The collection from artillery and hydrologic (TOE 5-500) elements of meteorological data for use in target analysis.

e. The processing and dissemination of ADM reconnaissance.

f. The maintenance of a current ADM reference file and ADM mission target analysis/evaluation folders.

g. Security measures applicable to ADM storage, movement, and emplacement in coordination with the S3, S4, and supported and supporting units.

h. The supervision of administrative personnel procedures to insure that only those authorized by current Army regulations are granted access to ADM defense information.

4-3. Operations Officer (S3)

The engineer operations officer has the primary staff responsibility for ADM employment. Specifically, his responsibilities include—

a. Preparation of the unit ADM SOP and technical advice for and coordination of the ADM SOP of supported and subordinate units. (See format, app. IV.)

b. Maintenance of unit ADM training records.

c. Supervision of the unit ADM training program (para 4-7).

d. Direction of detailed target evaluation of selected ADM targets based on command guidance, the unit SOP, staff recommendations, and the requests of supported units.

e. Recommendations as to the requirements for ADM teams and other engineer support required for specific targets.

f. Fallout and surface water contamination prediction from friendly ADM employment in coordination with S2 and appropriate CBR element.

g. Coordination of matters relating to ADM operations with other staff members, subordinate units, and supported units to include points and times of ADM pickup, emplacement construction, rendezvous points, security detachments, transportation means, and routes to emplacement sites.

h. In cooperation with the S4, maintenance of records to show current status of available ADM to include actual locations, unit or installation custodian, and state of readiness.

4-4. Supply Officer (S4)

The supply officer has primary staff responsibility for the provision of ADM and associated equipment. Specifically, the S4—

a. Procures and issues construction materials and required ADM tools, sets, and kits to subordinate units.

b. Coordinates pickup and transportation procedures for ADM through close liaison with the supporting SASP.

4-5. Intelligence Reports

Strategic intelligence studies prepared at the National level by the Department of Defense (DOD) or by oversea commands provide detailed information concerning major geographical areas and are often useful in preliminary ADM targeting. Such studies include—

a. National Intelligence Surveys. These surveys present a concise digest of the basic intelligence required for strategic planning and the operations of major units. Each survey describes the pertinent terrain characteristics of a specific area, supported by descriptive material such as maps, charts, tables, and bibliographies.

b. Engineer Intelligence Studies (EIS). These are a series of documents describing in detail those natural and manmade features of an area that affect the capabilities of military forces. These studies are being supplemented and in some cases superseded by DOD and command-initiated lines of communications, port, and terrain-type studies.

c. Lines of Communication (LOC) Studies. These studies, prepared on either medium scale maps or single small scale foldup sheets, contain an analysis of transportation facilities with general information on railroads, inland waterways, highways, airfields, pipelines, ports, and beaches.

d. Route Reconnaissance Reports. Most important for terrain information at lower levels are local reports which summarize data obtained by physical route reconnaissance. Such reports are of particular value in providing current, detailed information about routes of communication. The preparation of these reports is discussed in FM 5-36.

e. Demolition Reconnaissance Records (DA Form 2203-R). The preparation of these conventional demolition records is discussed in FM 5-25.

4-6. ADM Target Reconnaissance

a. Successful execution of ADM missions usually depends on prior reconnaissance of the target area and emplacement site. In most cases, ground reconnaissance is required to provide necessary data for detailed target analysis; however, reconnaissance by aircraft can locate potential targets and speed engineer reconnaissance teams to the general target location. The intelligence officer bears staff responsibility for the location and processing of target data. Nevertheless, all combat engineer officers and designated enlisted personnel must recognize potential ADM targets and be familiar with the method of reporting target information.

b. ADM target reconnaissance requires that members of the reconnaissance teams have a general knowledge of nuclear effects and how these effects achieve target damage. The reconnaissance team leader should be capable of determining the governing nuclear effect for each ADM target to insure that appropriate information is reported for complete target analysis. Although ADM are most often used against point targets, the reconnaissance team must not forget that ADM are also capable of large area destruction. Once the char-

acteristics of the specific target are recorded, the reconnaissance team proceeds to investigate the surrounding area for other elements that may be affected by the burst. The location or proposed location and type of protection afforded to friendly troops in the vicinity of ground zero is vital in planning ADM missions. Other considerations such as the location of nearby forests or population settlements may also be of importance. In cratering, soil type is of critical significance as well as the proximity of bypasses which may reduce an obstacle's effectiveness. Chapter 6 outlines the specific information upon which detailed target analysis is based.

c. Command sites and alternate command sites are selected during reconnaissance (para 4-21). Concealed routes of withdrawal to areas of protection against nuclear effects are also selected for the demolition guard and firing party. Each route is reconnoitered and the withdrawal time noted.

d. If emplacement holes or other emplacement methods beyond the capabilities of ADM teams are required, such information together with an estimate of the number and type of engineers, equipment, and time necessary to prepare the target for demolition is recorded. When aerial delivery of ADM is contemplated, suitable landing areas are also reconnoitered and reported by the reconnaissance party.

e. To facilitate a uniform method of recording and reporting potential ADM targets, reconnaissance forms similar to that shown in appendix IV may be locally produced. Such forms provide uniformity in reporting target information and are designed for electrically transmitted as well as written reports.

4-7. Engineer ADM Training

a. Schools for training ADM specialists have many facilities and aids that are difficult or impossible to duplicate in the field. Engineer units obtain and utilize school-trained personnel whenever possible. Moreover, unit training in coordinated ADM operations must be continuously conducted. On-the-job training is required to develop proficiency in technical procedures and to provide additional qualified

specialists. On-the-job training conducted by units should make maximum use of standard and expedient training equipment and school-published training materials to enhance instruction. Personnel must be given instruction on the unit ADM SOP as well as their individual specialties. Unit training records are maintained as a basis for periodic refresher training.

b. Specially skilled personnel and special equipment may be required to support the pre-fire team by the preparation of the emplacement and command sites. Practical exercises in these functions provide excellent training for personnel involved. The organization of an ADM demolition firing party to accomplish the above support functions and the prefire operations should be included in the unit SOP. Within the prefire element, individuals should be cross trained in all test and prefire procedures to provide depth and, thereby, insure that the team will function efficiently in the event of casualties.

c. In addition to normal training records, engineer units maintain ADM training records. These records reflect the names of personnel qualified to perform prefire and test procedures, their security clearances, their type of training (school trained or unit trained), manuals available in a current ADM reference file, and whether or not personnel have read appropriate manuals and changes.

d. Inspections should be conducted to determine the technical proficiency of personnel and to evaluate other factors affecting the unit's ability to conduct ADM missions. To better determine a unit's ability to deliver and emplace ADM reliably, a nuclear weapons exercise should be conducted as a phase of field exercises. Such exercises, conducted under conditions similar to those expected to be encountered in an actual mission, provide a basis for determining the unit's ability to perform the following:

- (1) Pickup, handling, transporting, and storing munitions.
- (2) Partial storage monitoring.
- (3) Unpackaging and repackaging procedures.

- (4) User maintenance.
- (5) Prefire and test procedures.
- (6) Procedures for delayed or canceled missions.
- (7) Emplacement procedures.
- (8) Accident and incident control and reporting.
- (9) Troubleshooting procedures.
- (10) Preparation and maintenance of records and reports.
- (11) Safety and security procedures.
- (12) Emergency destruction procedures.

4-8. Transportation of ADM

During transport, engineer personnel normally accompany ADM from the special ammunition supply point (SASP) to the emplacement site. Practically any vehicle of suitable capacity can be used, including Army aircraft or boats, and, for some munitions, pack animals or men. Transportation requirements must include lifting and loading equipment for handling the larger munitions. Wreckers, cranes, rail systems, or fabricated ramps are some expedients that may be used. Tactical security considerations determine the vehicular convoy composition and the strength of the security forces necessary for escort. The overall command of the convoy may be specified in the orders to the demolition guard commander or in the engineer unit ADM SOP. To insure reinforcement in case of an emergency, the convoy commander maintains continuous communication with higher headquarters.

4-9. Storage and Maintenance

a. Depending upon the disposition of ADM, engineer units may be directed to carry ADM as prescribed nuclear load (PNL).

b. Temporary storage of war reserve ADM must meet the requirements listed in appropriate technical manuals and Army regulations (app I). These requirements are for war reserve ADM only and do not pertain to unclassified training items or simulated munitions used for exercise purposes. Except in emergency, ADM are not stored until these facilities are available. However, in fluid tactical situa-

tions, increased reliance is placed on the use of armed guards instead of fixed installations.

c. Engineer units having custody of ADM are responsible for certain inspection and maintenance duties. Inspections generally are limited to partial storage monitoring in accordance with the instructions contained in applicable technical manuals (app I). The engineer unit may request advice and assistance from special ammunition units. Also the engineer unit SOP should provide general guidelines in both storage and maintenance procedures.

4-10. Test and Prefire Procedures

The time required to test and prefire an ADM depends largely upon the proficiency of the demolition firing party. To reduce time required at the emplacement site, as many test and prefire operations as possible are performed in a secure rear area. Thereafter, the munition is handled and transported with extreme care so that tests are not invalidated or the munition rendered unreliable. Detailed prefire procedures are contained in the technical manuals for each munition (app I).

4-11. Emergency ADM Denial

a. To prevent the enemy from capturing ADM intact or reconstituting munitions by cannibalization, emergency denial operations may be authorized. Emergency denial is considered as part of ADM mission planning. Authority to implement emergency denial must be clearly stated in the unit SOP and ADM team members must be thoroughly trained in emergency destruction methods. Methods of denying munitions and related materiel are—

- (1) *Evacuation*—the safing and recovery of munitions and components for future use.
- (2) *Emergency destruction*—the blasting, mutilating, fragmenting, and burning of munitions and components. Instructions for destruction are found in the appropriate technical manuals (app I).

b. In emergency denial, the following priorities are observed:

- (1) Nuclear components.
- (2) Associated classified materiel, equipment, and documents.
- (3) Unclassified documents and materiel.

4-12. Timer Option

a. To insure positive control and safety for ADM missions in which a timer option is employed, accurate timer calculations are essential. Moreover, in the event of a canceled or delayed mission, it is important for the protection of recovery or disarming personnel that the time of detonation has been precisely determined and recorded. Timers may be used as either a primary or secondary (backup) means of detonation. When timers are employed, it is *not* possible to state that an ADM will fire at a specific time. There is always a time span or *span of detonation* involved.

b. The *span of detonation* is that total period between the earliest possible time of detonation and the latest possible detonation time. This time span is due to the integral timer error. *Early time* is the earliest possible time that the munition can detonate because of timer error. Conversely, *late time* is the latest possible time the munition can detonate. *Fire time* is that time when the munition will detonate should the timers function precisely without error. In other words, *fire time* is that time of day resulting from the addition of the time physically set on the timers to the time

of day the timers are started. This *fire time* falls between *early time* and *late time*, but is not necessarily the midpoint in the *span of detonation*. *Starting time* is the actual time that the timers are started. *Set time* or *total time* is the time actually set on the timers and encompasses the entire period from starting time to fire time. An illustration of these time factors appears in figure 4-1.

c. There are four basic types of timer calculations that the prefire team may be required to make—

- (1) Given the time and the fire time: find the early, late, starting, and total times.
- (2) Given the early and late times: find the starting, fire, and total times.
- (3) Given the starting and early times: find the late, fire, and total times.
- (4) Given the starting and late times: find the early, fire, and total times.

d. When timers are utilized to backup the remote option, a special problem arises. This problem is to calculate the *total time* physically set on the timers so that they will positively run down and initiate the ADM no earlier than the prescribed *fire time* of the remote option but as close to that time as possible. The calculation for timer option is accomplished by utilizing the *fire time* with the remote option as the earliest possible detonation time.

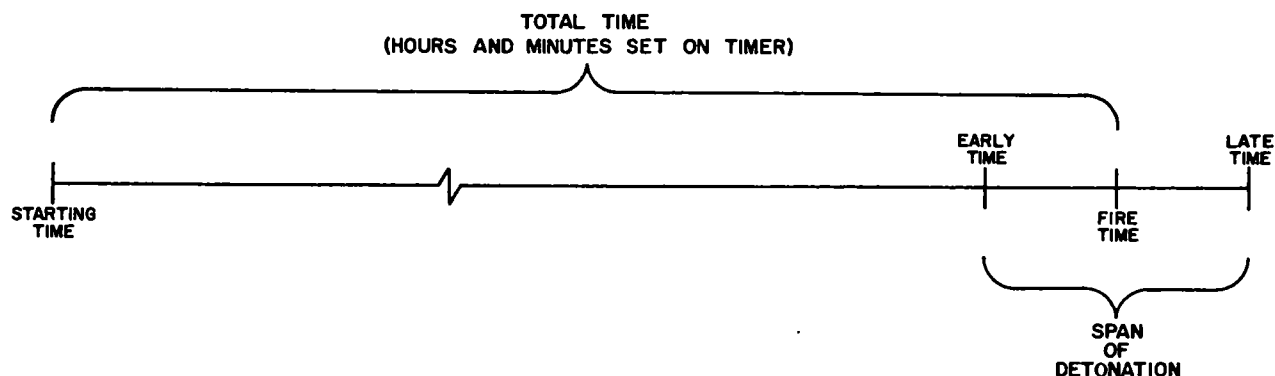


Figure 4-1. Timer calculations.

Section II. ENGINEER ADM UNITS

4-13. General

To provide ground forces with a capability for atomic demolition munitions employment, engineer ADM teams and platoons have been organized. These ADM units provide technical requisites for the execution of ADM missions; however, additional combat and combat service support must be furnished before mission implementation. Normally, ADM teams are assigned or attached to other combat engineer organizations for logistical and administrative support. Upon receipt of an ADM mission and in accordance with the type, magnitude, and number of targets in the employment area, ADM units usually are attached for command and control to the tactical formation charged with the execution of the mission and for the duration of the specific operational phase. ADM units are capable of providing technical advice for ADM employment; technical supervision in the preparation of sites to meet ADM emplacement requirements; performance of all prefire checks; and, on order, detonation of the munition. The engineer ADM emplacing element also provides physical security for the munition and associated classified equipment. The safeguarding of ADM defense information is a command responsibility which ultimately rests with the ADM unit leader. The ADM unit leader must explain the security precautions required in safeguarding ADM defense information to and coordinate security requirements with the supported unit commander. The supported unit must assist in establishing and meeting these security requirements.

4-14. Atomic Demolition Munition Teams

In order to achieve maximum flexibility and to reduce manpower and training requirements, three types of ADM teams are organized (TOE 5-570). Each team is dependent, however, upon the unit to which attached for combat support, combat service support, and tactical and local security.

a. Atomic Demolition Munitions Platoon Headquarters, Separate (TEAM MA).

(1) This team provides qualified personnel and necessary equipment for the command and control of an ADM platoon composed of from two to six atomic demolition munitions teams (MC). The team may be attached to an engineer combat group or battalion (Army), other U.S. combat units and task forces, or allied military organizations. The team consists of a platoon leader, platoon sergeant, general clerk, radiotelephone operator, and light truck driver.

(2) The platoon leader commands the platoon and is responsible for its training and technical employment. In addition, he serves as a special advisor in ADM operations to the unit to which attached. Upon detachment of subordinate teams for a specific ADM mission and in accordance with the tactical situation and size of the ADM platoon, the platoon leader may assume command of a portion of the platoon placing the remainder of the platoon under the command of the platoon sergeant; or he may conduct liaison between the deployed ADM teams and the supported headquarters coordinating matters of ADM employment and associated matters of communications, supply, and security.

☆ (3) The platoon headquarters is fully mobile and has organic radios for communications between elements of the platoon and higher headquarters.

b. Atomic Demolitions Munitions, Liaison (TEAM MB). This team consists of an ADM liaison officer and a driver. The liaison officer acts in the capacity of a special staff officer providing technical knowledge and advice for ADM employment. The team may be attached to a U.S. Army unit or allied unit which requires technical assistance in ADM employment. In addition to this staff function, Team MB performs liaison between the headquarters

to which attached and other supporting or attached ADM teams. The team is furnished a ¼-ton utility truck.

★ *c. Atomic Demolitions Munitions Squad (TEAM MC).* This team consists of the team leader and four ADM specialists and is responsible for the assembly, preparation for firing, and detonation on order and, if necessary, the recovery, disassembly, or destruction of ADM. The ADM team is dependent on the unit to which attached for ADM storage, resupply, additional transport, tactical and local security, site preparation, and similar types of combat and combat service support. The squad may be assigned on the basis of one or more to the engineer combat battalion (Army), other U.S. Army combat units and task forces, allied forces, or to increase the capability of the divisional ADM platoon. When two or more of these teams are formed into a platoon, Team MA provides the necessary command and control. Each Team MC is fully mobile and is equipped with sufficient radios for both internal and external communications. The squad may be divided to provide two ADM assembly teams under conditions of extensive ADM use. The second team must, however, be supported with transport and communications.

★4-15. Divisional ADM Platoon

a. Each engineer battalion organic to the armored, infantry, and infantry (mechanized) division includes an ADM platoon. These platoon

toons include a platoon headquarters and two ADM squads. Platoon headquarters consists of the platoon leader, platoon sergeant, a senior ADM specialist, a radio-telephone operator, and a clerk. Each ADM squad consists of a squad leader, two senior ADM specialists, and two ADM specialists. The platoon is fully mobile and is equipped with sufficient radios for both internal and external communications.

b. The responsibilities and operations of the ADM platoon leader are similar to those outlined for the platoon leader of Team MA. In addition, the platoon leader serves as a special advisor for ADM technical employment within the division. The capability of the divisional ADM platoon may be augmented by the attachment of one to four ADM squads (Team MC) under which circumstances the platoon leader assumes command of all attachments.

c. The divisional ADM platoon is dependent upon the assistance of the parent engineer battalion as well as other division elements for operation effectiveness. Close coordination is maintained with the engineer battalion staff to insure that procedures are established to provide each ADM mission with adequate and timely support. The ADM platoon leader maintains particularly close liaison with the engineer battalion operations section and may be called upon to assist in the technical preparation of the atomic demolition plan and the unit ADM SOP.

Section III. ENGINEER COMBAT SUPPORT

4-16. General

As previously noted, ADM units do not have the capability of conducting independent operations. Successful ADM employment requires detailed staff planning and coordination. Routinely, ADM units are assigned or attached to engineer combat battalions prior to operational employment, and it is the responsibility of these battalion headquarters to insure that efficient ADM standing operating procedures have been established and engineer personnel are trained to effectively accomplish ADM mis-

sions. Engineer battalion commanders and staffs continually supervise and coordinate the activities of assigned or attached ADM units. The success or failure of ADM employment rests, to a large extent, on the prior training and efficiency of the supporting combat engineer battalion as a whole. All combat engineer commanders must be familiar with the special considerations of ADM operations and emplacement site preparation, and their units must be ready to respond immediately to the requirements of the specific situation.

4-17. Security

Although local security of ADM often may be furnished by nonengineers, it is incumbent on all engineer combat units, platoon and above, to be capable of providing well trained security guards when called upon. Engineers frequently escort ADM from the pickup site to emplacement sites; in other instances, combat engineer units may be designated as demolition guards in which case local security of the ADM mission becomes a direct engineer responsibility. Moreover, engineer combat units, based on their close association with ADM, may be called upon to establish basic ADM security procedures for the entire command.

4-18. Construction Support

a. ADM emplacement methods vary from simple surface bursts to deep underground burial. As ADM teams have no organic equipment for preparation of emplacement holes, other engineers are often required to support emplacement operations. For example, many ADM emplacement techniques require tamping with sandbags which are most easily supplied by supporting engineers. Engineers may also construct field fortifications for the protection of ADM command sites or improve access routes to emplacement sites. Moreover, the security of ADM sites may be significantly augmented by the installation of mines, barbed wire, and similar obstacles. Such engineer support is beyond the capabilities of ADM teams and is effected through coordination at battalion and higher unit headquarters.

b. The cratering curves presented in chapter 6 demonstrate the influence of depth of burst on crater dimensions. In tactical ADM operations the depth of burst ordered for a given mission will depend on the tactical situation and the availability of time, manpower, and suitable construction equipment. Even though burial at optimum depth is not feasible, burial at depths less than optimum will increase crater dimensions over those obtainable by a surface burst.

4-19. Methods of Emplacement

★ a. Emplacement methods fall under the

general categories of deliberate and hasty emplacement. A deliberate emplacement is one which is specifically prepared to optimize the desired effects of a particular munition to accomplish a particular mission. Deliberate emplacement may require the use of tunneling or drilling procedures to provide underground emplacements or the construction of a demolition chamber at the desired location on a bridge or other surface structure. Hasty emplacement refers to expedient methods of surface emplacement to include attachment of the ADM to existing structures, shallow burial, and the use of existing shafts, tunnels, etc. Hasty emplacements are used only when there is insufficient time or equipment available to prepare a deliberate emplacement and will normally require the use of a higher yield and acceptance of greater safety hazards to produce the same degree of destruction.

b. The physical characteristics of ADM and environmental limitations determine to a large extent the possibility of rapid subsurface emplacement. A list of required emplacement diameters for the hypothetical family of ADM as well as their subsurface limitations is presented in table 3-1.

★ c. In tactical situations where emplacement resources are limited and secrecy is important engineer handtools are used to bury the ADM as deep as practical. In less restrictive situations powered equipment or demolitions may be employed in preparing the emplacement.

- (1) The powered earth auger offers a rapid means of excavating emplacement shafts up to 20 inches in diameter and 9 feet deep. This item is organic to the Light Equipment Company and the Engineer Construction Battalion and also may be available from a Class IV equipment pool.
- (2) In appropriate situations military explosives may be used alone or in conjunction with either powered equipment or handtools to prepare ADM emplacements.

★ d. Paragraph 6-6b contains additional information on emplacement criteria.

★4-20. Tamping and Stemming

a. The detonation of an ADM releases energy in all directions. To couple the greatest possible portion of this energy to the target it is necessary to confine the explosion to the maximum extent possible. For a surface or tunnel emplacement this process is called *tamping* and the material used is also called *tamping*. For a subsurface emplacement shaft both the process and the material used to fill the shaft are called *stemming*.

b. The most suitable materials for use as tamping or stemming are, in order of desirability, dry sand, dry gravel, or compacted earth. Sandbags may be used if carefully placed to minimize voids. Other materials such as broken rock or water will provide partial tamping or stemming. Figure 4-2, shows the recommended method of stemming a subsurface emplacement shaft.

c. The decision as to the type and quantity of tamping or stemming to be used depends on many factors, among which are—

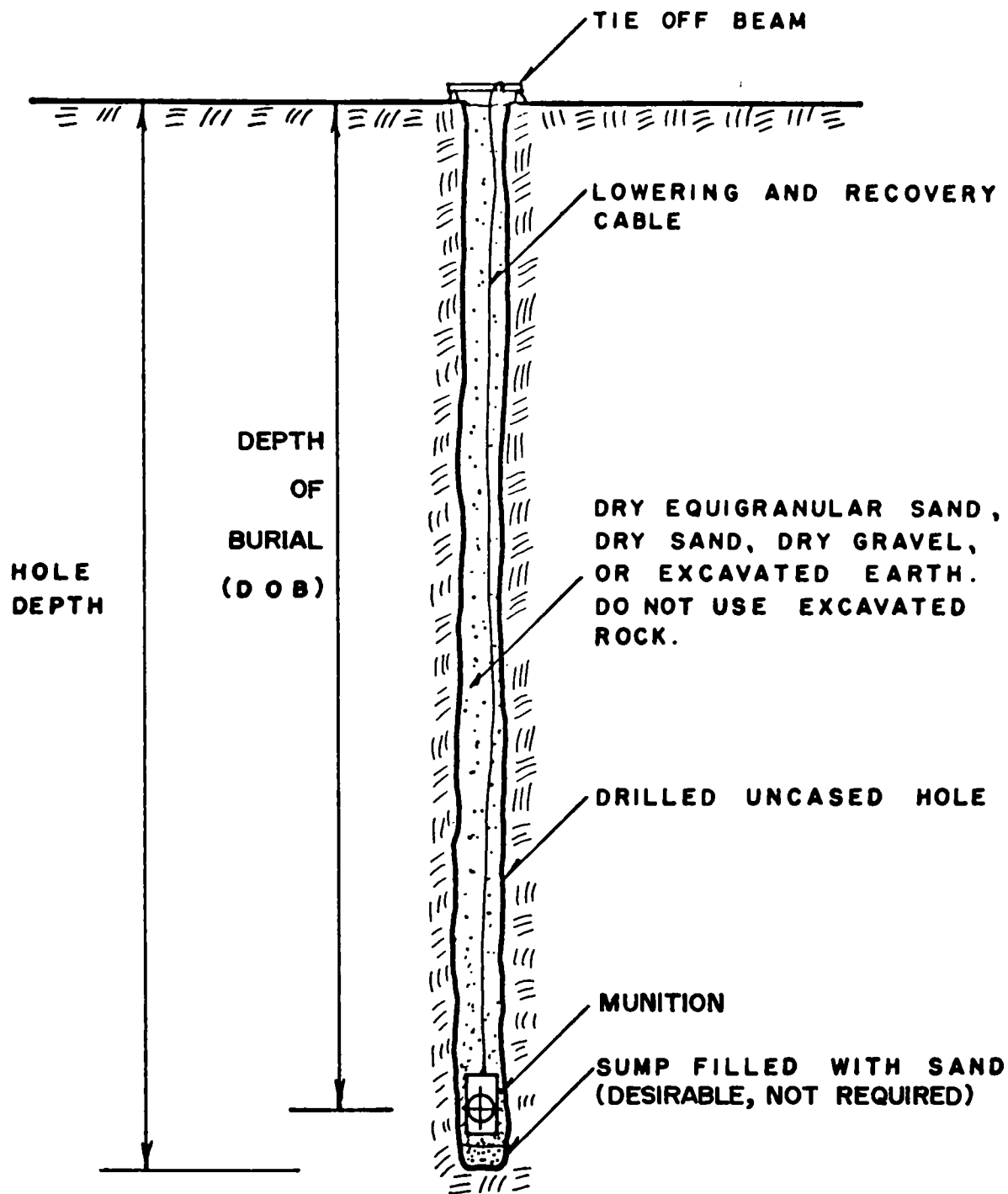
- (1) Type, quantity, and location of materials available.
- (2) Time and resources available.
- (3) Requirement for insuring recoverability of the ADM in case the mission is canceled.
- (4) Degree of predictability of effects required.

d. Paragraph 6-7 contains information on prediction of effects when tamping or stemming is less than optimum.

4-21. Preparation of Command Sites

a. Supporting engineer units are often designated to prepare primary and alternate command sites. Although priority is given to the preparation of the primary command site, alternate sites are normally planned, coordinated, and prepared. Alternate sites insure completion of the mission, provide flexibility, and permit safe firing under variable meteorological conditions.

★ b. Command sites (and any other sites designated for protection of demolition guard or firing party personnel at the time the munition is detonated) are far enough from the ADM to insure that the demolition guard and firing party are not subjected to initial nuclear effects greater than that specified by the commander. Locations should also consider anticipated fallout although a change in meteorological conditions may dictate detonation of the ADM from an alternate command site. Intervening terrain features may reduce some of the initial nuclear effects; however, terrain masks should not obscure observation of the emplacement site. If direct observation of the emplacement site is not possible, observation may be maintained by aerial surveillance.



★ Figure 4-2. Stem design for subsurface emplacement of ADM.

CHAPTER 5

ADM TARGET ANALYSIS

Section I. GENERAL

5-1. Factors Considered in ADM Target Analysis

a. General.

- (1) ADM target analysis is an examination of potential targets and surrounding areas to determine military importance, priority of demolition, and munitions required to obtain a desired level of damage. The purposes of analysis are to compare the respective advantages of conventional and nuclear demolitions in achieving desired target damage, to select the most suitable munition available, to investigate the degree and extent of secondary nuclear effects, and to predict conditions in the target area after detonation.
- (2) Nuclear targets are classified according to size, as follows:
 - (a) *Point targets.* A point target may be either a single element type of target such as a bridge, or it may be an area target whose radius is relatively small in comparison to the radius of damage (about 1 to 5).
 - (b) *Area targets.* Larger targets which occupy a sizeable portion of terrain are termed area targets.
- (3) Predicted results for area targets include the fraction of the target area which is expected to be destroyed and is usually expressed as a percentage. For point targets, damaged chiefly by cratering effects, a brief description of damage is required; *for example:* "center pier of bridge and adjacent spans destroyed."

b. *Assumptions.* Analysis is based on the following assumptions:

- (1) *Reliability.* It is assumed that the ADM will be successfully detonated.
- (2) *Area targets.* ADM are normally employed after detailed ground, air, and map reconnaissance of the target area; however, if detailed information is not available, elements of area targets are assumed to be uniformly distributed.
- (3) *Atmospheric conditions.* The influence of atmospheric conditions on initial nuclear effects is not usually considered by the target analyst.
- (4) *Terrain.* If a nuclear detonation occurs within a narrow defile, initial nuclear effects may be reinforced within the valley and reduced outside of valley because of the shielding afforded by the terrain.
- (5) *Burial.* In many instances, damage is predicated upon adequate ADM burial. In tactical situations, the target analyst must be familiar with the burial capabilities of emplacement units and base his analysis on practical construction limitations.

5-2. Data for ADM Target Analysis

a. Tables in appendix II and FM 101-31-2 present technical data to be used in ADM target analysis. These ADM damage tables provide data for most demolition targets. Troop safety tables and contingent effects tables are also included.

b. *The troop safety tables* simultaneously consider initial nuclear effects and the degree of risk to friendly troops in a particular con-

dition of vulnerability. The tables give the minimum distances that friendly troops must be separated from ground zero to preclude casualties under various conditions of risk and vulnerability. These minimum safe distances (MSD) are based on surface burst initial effects only and do not take into account residual radiation or radiation history (para 5-7).

c. The *damage tables* consider ADM nuclear effects based on surface and/or subsurface bursts. For each ADM, radii of damage against various target elements are shown.

★ d. The *contingent effects tables* consider only surface burst effects. For each munition, the tables present the distance to which various effects extend. These effects are—

- (1) Tree blowdown.
- (2) Safety radii for aircraft in flight.
- (3) Fire areas.

e. The tables in FM 101-31-2 have been computed for ADM in the United States stockpile whereas those in appendix II have been computed for a hypothetical family of ADM (table 3-1). The formats, however, are similar. One who understands the techniques of using the unclassified tables can readily make the transition to the classified tables contained in FM 101-31-2.

5-3. Recommendations

a. *General.* One purpose of target analysis is to select the most suitable ADM for destroying the target under consideration. After target analysis has been completed, the following recommendations are presented to the commander:

- (1) Primary and alternate yields with associated munition types.

- (2) Height or depth of burst.
- (3) Location of ground zero.
- (4) Point of detonation, if applicable.
- (5) Time of burst and firing options.
- (6) Estimated results.
- (7) Troop safety distance.

b. *ADM Model and Yield.* The ADM model and yield to be employed is represented as shown in table 3-1. For example: BRAVO/1KT/ADM.

c. *Height or Depth of Burst.* Burst option is normally indicated as surface or subsurface and includes the exact height or depth of burst in meters when applicable.

d. *Ground Zero.* Ground zero (GZ) is the point on the earth's surface at which, above which, or below which, the detonation will occur; GZ is generally designated by UTM map coordinates.

e. *Point of Detonation.* In cases where structures are involved, the point of detonation (burst point) is also specified; for example: base of center pier.

f. *Time of Burst and Firing Options.* The time of burst and firing options are determined by both tactical and technical considerations, such as the scheme of maneuver and timer error; it is shown as a date-time group.

g. *Troop Safety.* The distance to which the effects for negligible risk to unwarned, exposed personnel extend is portrayed graphically to the commander. If friendly troops are located within this distance, a graphic presentation is provided depicting the resultant risk and/or protection required. (For further discussion of troop safety, see (para 5-7 and ch 7).)

Section II. TECHNIQUES OF ADM TARGET ANALYSIS

5-4. General Procedure for Analyzing Targets

The following general procedural steps are those used by the target analyst. They serve only as a guide. Some steps may be omitted or changed in order to meet the needs of the ex-

perienced target analyst. These procedural steps closely parallel techniques outlined in appendix IV, FM 101-31-1, particularly in those cases where blast damage constitutes the governing ADM effect.

a. *Step 1—Identify Pertinent Information.*

weapon yield being investigated falls in the range where radiation is the governing troop safety criteria. If radiation does not govern, the unit's radiation history does not have to be considered. If radiation does govern, the unit's radiation history must be considered and both table II-8 and criteria of paragraph 7-4 must be consulted. The criteria shown in paragraph 7-4 should be interpreted as follows:

- (1) For units with a past cumulative radiation dose of less than 75 rad (FRRS units), read direct from Troop Safety table II-8 for the appropriate risk and degree of vulnerability.
- (2) For units with a past cumulative dose of more than 75 but less than 150 rad (LRRS units), any future radiation exposure must be considered a moderate or emergency risk. There can be no negligible risk for personnel in this category. When investigating troop safety, the negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for moderate risk. Similarly, the moderate risk column must be used for determining emergency risk radii.
- (3) For units with a past cumulative dose of more than 150 rad (NRRS units), all future exposures must be considered emergency risks. There can be no negligible or moderate risk for personnel in this category. The negligible risk column and appropriate degree of vulnerability must be used to determine the MSD for emergency risk.
- (4) For units located adjacent to zone I or II of the predicted fallout area, exposures up to 20 rad after the onset of fallout could be received. Referring to criteria of para 7-4, if the unit was rated NRRS, this would exceed the emergency risk criteria of 5 rad or less. If the unit was rated LRRS, 20 rad would be an emergency

risk. If the unit was rated FRRS, the risk would be only moderate.

5-8. Contingent Effects

a. Contingent Effects. Contingent effects are divided into bonus effects which are desirable and limiting effects which are undesirable.

b. Bonus Effects. When an ADM is employed, there are many effects other than the governing effect which assist in destruction. Same bonus effects are predictable, others are not. The target analyst checks to see whether a predictable bonus effect exists at a certain point by obtaining the radius of damage for the effect from the contingency tables.

c. Limiting Effects. Limiting effects are those which are undesirable and, consequently, place restrictions on the employment of the munition. These restrictions are referred to as limiting requirements. Examples of effects which may be undesirable are the creation of obstacles to friendly movement as a result of tree blowdown, rubble, forest and urban fires, residual radiation, or undesirable damage in the vicinity of the burst. The target analyst determines whether undesirable effects will be created and determines the radius of the limiting effects from the contingent effects tables.

5-9. Analysis of Specific Target Types

a. The capability of ADM to destroy a specific target depends on many factors, the most important of which is the yield. When making a target analysis and selecting the yield, it is desirable to employ the lowest yield which provides the acceptable degree of damage to the target.

b. In chapter 6 special methods for analyzing ADM targets are presented. General analysis of each target type and specific factors regarding ADM employment are considered. Detailed analysis of typical ADM targets following the procedural steps outlined in paragraph 5-4 are presented in appendix VII.

5-10. Validity of Effects Data

a. Nuclear testing has produced the effects data on which target analysis is based. The validity of these data, however, is extremely variable; when required, validity application of these factors for each nuclear effect are given in TM 23-200. For target analysis purposes, the validity factors are not considered. The target analyst should have an understanding of the accuracy of the data. Refinement of the data or precision in using the data greater than that indicated in the recom-

mended target analysis techniques, therefore, is not justified.

b. Curves and other technical data are provided by the text so that reasonable estimates of yields or damage can be made. The data on which the curves are based have, in general, a degree of accuracy of plus or minus 25 percent. Knowledge of the cratering effects of ADM is rather limited. As a result, many of the procedures outlined are based primarily on theoretical data rather than empirical observations.

CHAPTER 6

SPECIAL ADM TARGET ANALYSIS

Section I. INTRODUCTION

6-1. General

Unlike other nuclear systems, ADM are employed to destroy hard targets rather than cause personnel casualties. Nuclear cratering, therefore, is usually the governing effect, whereas other nuclear effects are considered only as bonus. In addition, the unique characteristic of no delivery error considerably simplifies target analysis techniques. This chapter, therefore, presents modifications to the general target analysis methods outlined in FM 101-31-1 and provides special techniques for the analysis of typical hard targets.

6-2. ADM Target Analyst

Since ADM are most often employed to destroy hard targets, the ADM target analyst

must not only be qualified in estimating the effects of nuclear detonations but be familiar with basic construction design. Moreover, the surface and subsurface employment of ADM is significantly influenced by the surrounding soil media and presents an additional area of interest for the ADM target analyst. ADM target acquisition is similarly diversified requiring not only target location but a detailed description of the target including critical structural dimensions, burial limitations, and soil characteristics. Because of his background and training, the military engineer is well qualified to perform the multiple tasks of troop commander, nuclear target analyst, structural engineer, and soil analyst which are prerequisite to ADM employment.

Section II. TACTICAL CRATERING

6-3. General

One of the potential military uses of ADM of prime significance is the creation of terrain obstacles. The nuclear cratering effect has been previously discussed in general terms in chapter 2. The purpose of this section, therefore, is to present techniques of using ADM to displace large masses of soil or rock to deny land routes of communication in support of tactical operations.

6-4. Mechanisms of Crater Formation

In order to use the cratering data presented in this manual, the target analyst and engineer should be familiar with the mechanisms of crater formation. Four important processes are involved—

a. The first process is the combined action of crushing, compaction, and plastic deformation that occurs in the media surrounding the nuclear detonation and is of major im-

portance for bursts at or just below the surface. The large pressures resulting from a nuclear detonation generate a shock wave which travels outward at a high velocity. Some material immediately adjacent to the detonation is melted and vaporized as the shock wave passes through it. The peak pressure in the shock front drops as the wave moves outward and as energy is expended in crushing, heating, and physical displacement. Even at greater distances, the pressures are still of sufficient magnitude to cause deformation in the plastic zone.

b. The second process is spalling. If the shock wave encounters a free solid surface (e.g.; a surface rock formation) as it travels outward, the mechanical phenomenon of spalling occurs. When the compressive stress exerted by the shock wave impinges on a free surface, a portion of the surface away from the detonation is broken off and moves out-

ward with considerable velocity. Successive slabs continue to break away until the energy is dissipated below the tensile strength of the material. Rock tends to spall along existing fractures and fissures. Spalling is of great importance in cratering and appears to be dominant for shallow burial.

c. The third process is gas acceleration. The first two processes described last only a fraction of a second. Gas acceleration, however, occurs over longer periods and imparts motion to the material surrounding the explosion by the adiabatic expansion of gases trapped in the cavity. In some instances, particularly for deeper depths of burst, this gas gives appreciable acceleration to the overlying material during its escape through cracks extending from the cavity to the surface as a result of the detonation. In many soil types, gas acceleration becomes dominant at optimum and slightly greater depths of burst. Desert alluvium is a good example of such material. In this soil type, cratering is enhanced by the formation of considerable quantities of steam and gas. Basalt, on the other hand, is an example of a material in which gas acceleration is not so important, as less gas is generated and the spalling effect accelerates the rock faster than the expanding gases.

d. The fourth process, subsidence, is most important for deep burial ($98 W^{0.3}$ meters or $320 W^{0.3}$ feet). Subsidence is closely linked with the combined process of crushing, compaction, and plastic deformation in vicinity of the burst point. The expansion of the high pressure gases generated by the explosion produces a cavity surrounding the detonation. When the pressure in the cavity decreases to the weight of the overburden, the roof of the cavity collapses forming a crater at the surface. The crater is parabolic in shape (fig. 2-2) with approximate dimensions as follows: Apparent diameter (D_A) = $73 W^{0.3}$ meters or $240 W^{0.3}$ feet and apparent depth (H_A) = $12 W^{0.3}$ meters or $40 W^{0.3}$ feet. Subsidence craters are not expected to be formed in hard rock media because there is appreciable bulking of the fractured material which falls into the cavity. In this case, the

volume of the underground cavity is not transmitted to the surface but is distributed in the form of voids extending throughout the region of fractured rock.

6-5. Effects of Depth of Burst and Material Properties

a. *General.* The role that each of the mechanisms described above plays in producing a crater is extremely dependent on the depth of burst. The dimensions of the produced crater, consequently, vary greatly with the ADM depth of burial. As the depth of burst increases, crater dimensions increase to a maximum at some optimum depth, then decrease until a depth of burst is reached where no crater is formed except for subsidence. The relationships of depth of burial and crater formation are applicable for most soil media. For a given energy yield, however, the maximum crater dimensions differ for various soils and occur at different depths of burst. Some of the properties of the surrounding media affecting the cratering process are the shock transmission characteristics, the tensile and shear strength, the extent of fractures and planes of weakness, moisture content, chemical composition, and density.

b. *Surface Burst.* The crater is produced primarily by compaction and plastic deformation. Scouring action by the initial gases also contributes to crater formation. The radius is extended to its maximum limit by spalling, but the major process for the depth of the crater and lip formation is the plastic deformation and compression of the material in the rupture zone. Very little fallback is found in a crater of this kind. Consequently, the true and apparent craters are approximately identical.

c. *Shallow Burial* (approximately $15 W^{0.3}$ meters or $50 W^{0.3}$ feet). At this depth of burst, spalling is the dominant process for the formation of the crater. Gas acceleration and scouring action are only of minor importance. The radius of the crater is determined by the spalling process, whose velocities decrease rather rapidly as the surface radius increases. This decrease of spall velocity folds back the

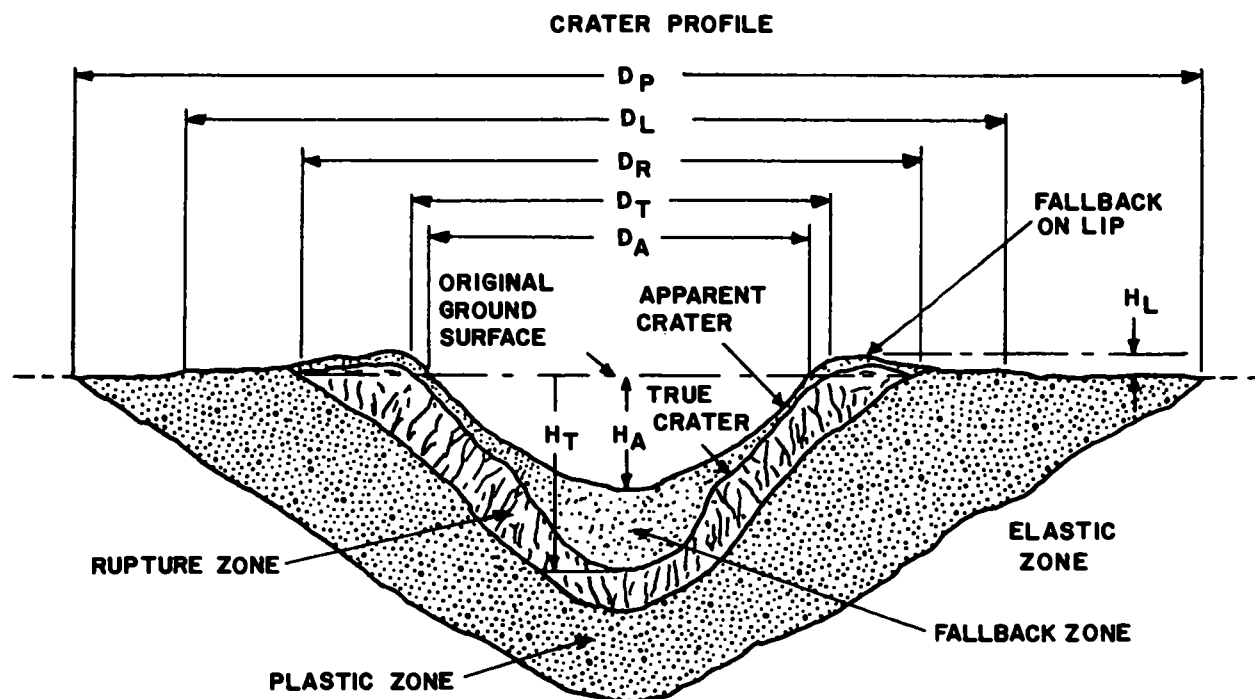
material on the edge of the crater to form a lip.

d. Optimum Burial. Optimum depth of burst is normally taken as that depth of burst at which the crater radius is maximized, (approximately $49 W^{0.3}$ meters or $160 W^{0.3}$ feet). At this depth of burst all three processes (plastic deformation, spall, and gas acceleration) contribute to crater formation.

e. Subsidence. See paragraph 6-4.

★6-6. Use of Cratering Curves and Scaling Laws

a. Figure 6-1 shows specific crater dimensions and the methods by which they may be derived for actual yields and depths of burst once basic data have been determined by scaling.



D_A = DIAMETER OF APPARENT CRATER

H_A = DEPTH OF APPARENT CRATER

D_T = DIAMETER OF TRUE CRATER

H_T = DEPTH OF TRUE CRATER

D_L = DIAMETER OF LIP = $2.0 D_A \pm 25\%$

R_A = RADIUS OF APPARENT CRATER = $\frac{D_A}{2}$

R_C = RADIUS OF CAVITY

$R_C = 45(W)^{1/3}$ FT OR $14(W)^{1/3}$ METERS

H_L = HEIGHT OF LIP = $0.25 H_A \pm 50\%$

D_R = DIAMETER OF RUPTURE ZONE
= $1.5 D_A \pm 25\%$

D_P = DIAMETER OF PLASTIC ZONE
= $3 D_A \pm 50\%$

V_C = VOLUME OF APPARENT CRATER
 $V_C = \frac{\pi}{2} H_A (R_A)^2$

$H_T = DOB + R_C$

Figure 6-1. Crater dimensions.

Definitions of zones of disturbance are given in paragraph 2-18. An empirical 0.3 power scaling law has been derived from past cratering tests. Using this scaling law, yields may be correlated to establish the relationship between crater dimensions and depth of burst by normalizing all dimensions to those applicable to a yield of 1 KT. The depth of burst and

crater radius resulting from a given yield are normalized by dividing by $W^{0.3}$. The yield (W) is expressed in kilotons. For surface bursts and for bursts at scaled depths of burst equal to or less than 1.5 meters (5 feet) the radius and depth of crater are scaled as $W^{1/3}$. These relationships are summarized below.

Subsurface burst ($DOB_2 > 1.5_m$)

<i>Depth of burst*</i>	<i>Radius of crater</i>	<i>Depth of crater</i>
$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$	$\frac{R_{A1}}{R_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$	$\frac{H_{A1}}{H_{A2}} = \frac{W_1^{0.3}}{W_2^{0.3}}$

Surface burst ($DOB_2 \leq 1.5_m$)

<i>Depth of burst*</i>	<i>Radius of crater</i>	<i>Depth of crater</i>
$\frac{DOB_1}{DOB_2} = \frac{W_1^{0.3}}{W_2^{0.3}}$	$\frac{R_{A1}}{R_{A2}} = \frac{W_1^{1/3}}{W_2^{1/3}}$	$\frac{H_{A1}}{H_{A2}} = \frac{W_1^{1/3}}{W_2^{1/3}}$

* See Figure 6-4.1 for effective depth of burst for DOB_2 to be used for various emplacement configurations.

b. Figures 6-2 through 6-4 give crater radius and crater depth as a function of depth of burst for various soil types. These curves are for a 1 KT ADM. The scaling laws given above must be used to find these dimensions for yields other than 1 KT. These curves assume that the emplacement of the ADM meets the criteria for "normal emplacement" as given in paragraph 6-7b.

★6-7. Effects of Tamping and Stemming

a. *General.* The manner in which the ADM is tamped or in which the emplacement shaft is stemmed determines the manner in which the energy from the explosion is coupled to the surrounding media. Thus several feet of tamping around a surface emplacement will reduce airblast and radiation to the atmosphere of all types and will result in a significantly larger crater than would be produced by the same munition in an untamped emplacement. Similar considerations hold true when comparing the effects of subsurface bursts in stemmed and unstemmed shafts.

b. *Standard Emplacement Configurations.* The curves given above (fig. 6-2-6-4) are

based on the following criteria: for a "surface burst" (depth of burst equals zero) it is assumed that the center of gravity of the nuclear portion of the weapon is in the plane of the surface of the ground and that no cover is provided; for a "subsurface burst" it is assumed that the emplacement shaft is completely filled with dry sand or earth.

c. *Nonstandard Emplacement Configurations.* Predictions of crater parameters for nonstandard emplacement configurations are based on theoretical analysis and very limited experimental results. Figure 6-4.1 shows both standard emplacement configurations and those nonstandard configurations for which meaningful prediction can be made at this time. Pertinent information governing the prediction of crater dimensions in each case is also shown.

d. *Expedient Surface Emplacements.* There is evidence that relatively small variations in surface emplacement configurations have great effects on crater parameters. For this reason it is important to insure that surface emplacements conform to those shown in figure 6-4.1 and that expedient emplacement,

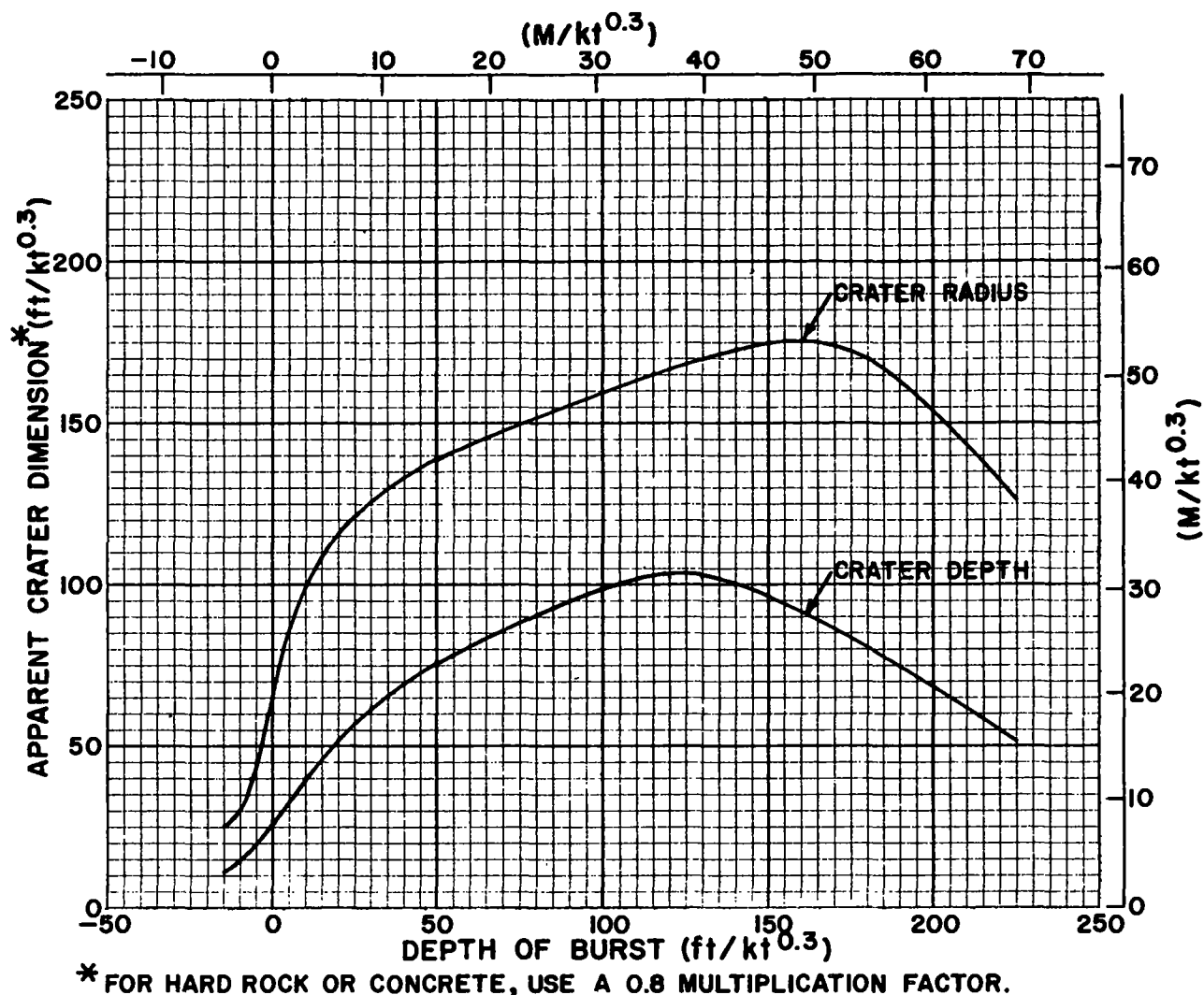


Figure 6-2. Apparent crater dimensions versus depth of burst in dry soil or soft rock (normalized to 1 KT).

such as the bed of a truck or trailer be rigorously avoided.

★6-8. Cratering in Various Media

Cratering data for various substances have not been fully developed. Sound engineering judgment and knowledge of the operational area are desirable in estimating specific crater dimensions. In this text, cratering data are provided for various media as follows:

a. Dry Soil and Soft Rock. Figure 6-2 gives the estimated apparent crater dimensions as a function of depth of burst for 1 KT bursts in dry soil or soft rock.

b. Hard Rock and Concrete. By using a multiplication factor of 0.8, the crater curves for dry soil and soft rock (fig. 6-2) may be used.

c. Wet Soils.

- (1) *Unconsolidated.* Marine muck typifies wet, sedimentary material and is composed of soft, very moist silts, clays, and organic deposits. These deposits are usually gray to blue if primarily silt, and yellow if primarily clay; figure 6-3 shows cratering curves for this soil type.

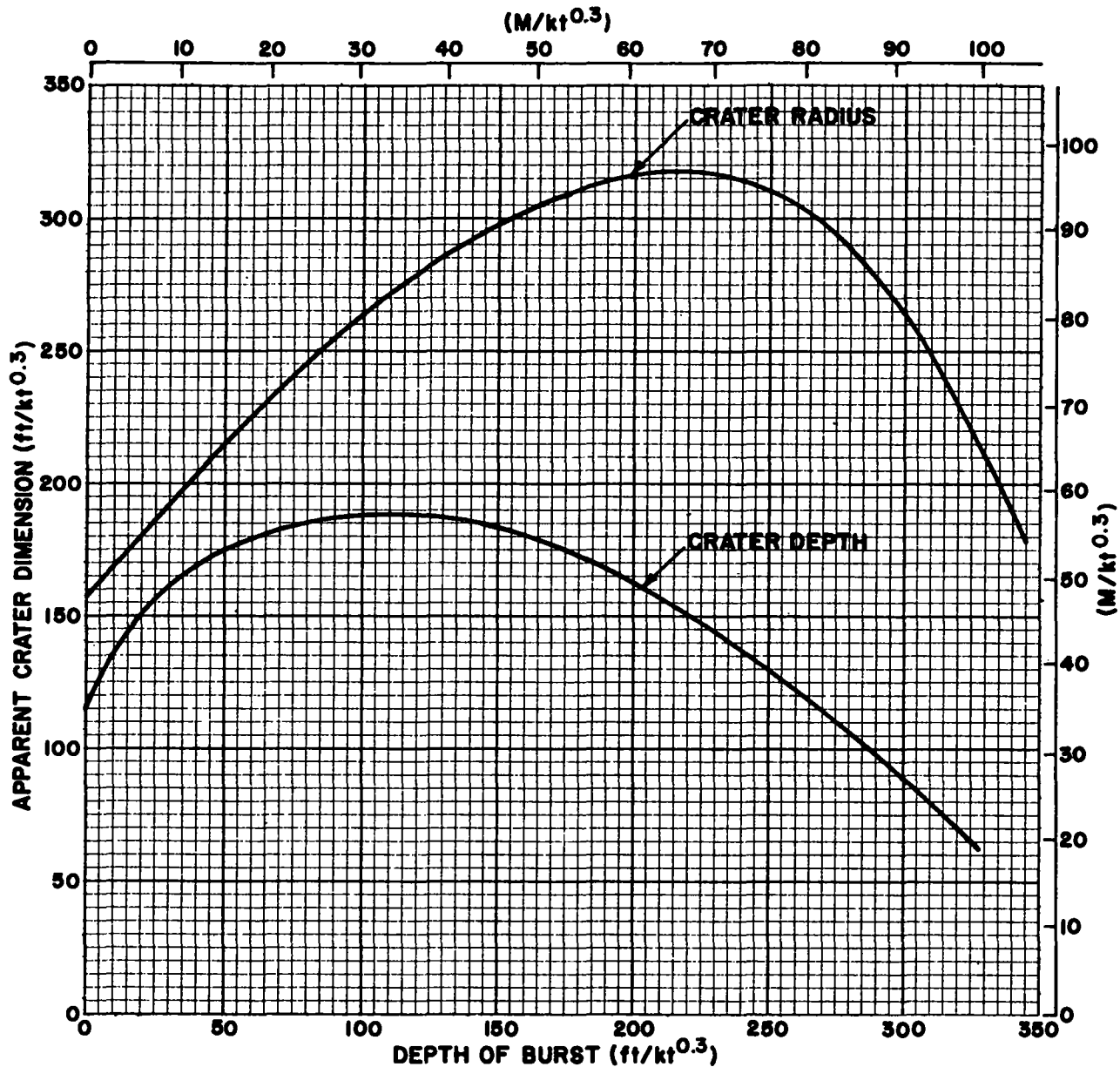


Figure 6-3. Apparent crater dimensions versus depth of burst in marine muck (normalized to 1 KT).

- (2) *Compacted.* Residual clay typifies material which consists of a compact, slightly plastic, cohesive clay. It is a residual product which has been developed by rapid rock decomposition inherent to regions of heavy rainfall, warm climate, and rank vegetation. The residual clay curves (fig. 6-4)

are used to predict crater dimensions in wet clay. A lower limit water content of 25 percent is used as the classification criterion for wet clay. Dry soil curves (fig. 6-2) are used to predict crater dimensions in soils with a moisture content less than 25 percent.

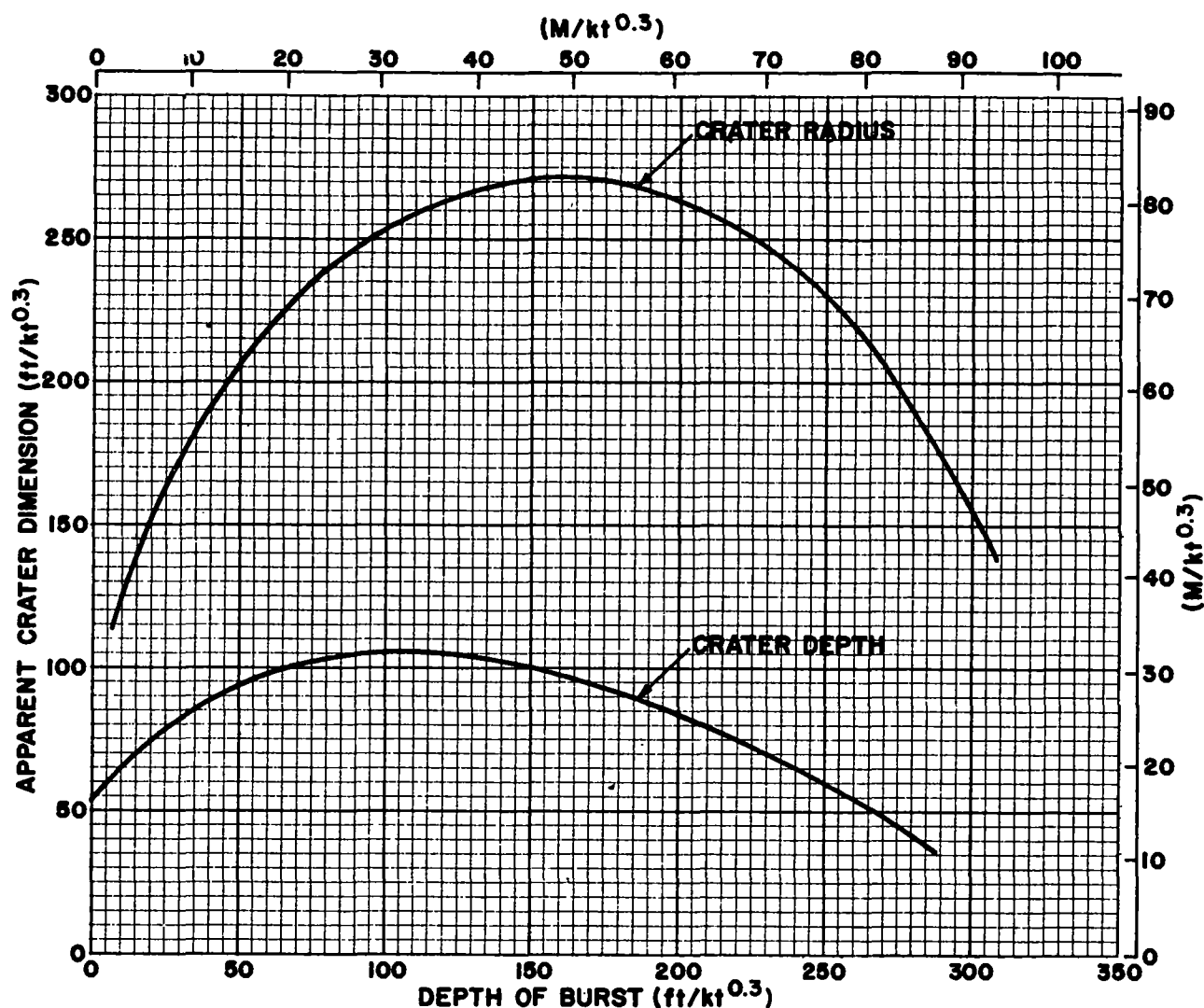


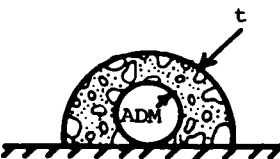
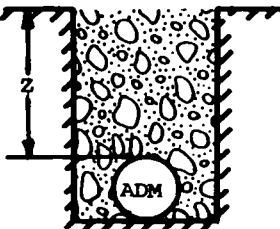
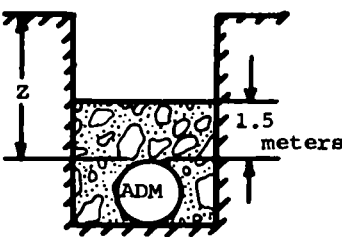
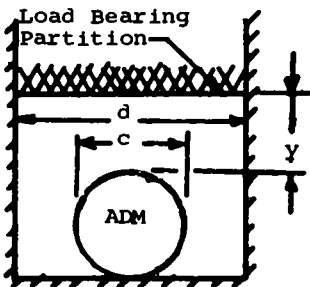
Figure 6-4. Apparent crater dimensions versus depth of burst residual clay (normalized to 1KT).

6-9. Apparent Crater Characteristics

a. *Shape of the Apparent Crater.* The shape of the apparent crater varies significantly with the depth of burst of the ADM. Craters resulting from surface detonations have gentle slopes and are relatively shallow in depth while detonations in the vicinity of optimum depth of burst produce craters with relatively steep slopes. Although the shape of the crater varies with depth of burial, the crater cross section remains approximately parabolic.

b. *Apparent Crater Lip.* The apparent crater lip consists of the material lying above the

original preshot ground surface. Formation of the apparent lip results from the upward displacement of the ground surface and the deposit of throwout material around the periphery of the crater. The upthrust portion of the lip is defined as the true crater lip, while the material deposited on top of the true crater lip (ejecta) combines with the true lip to form the apparent crater lip. The characteristics of the apparent crater lip depend on the yield, depth of burial, and the media in which the detonation occurs. Lip height and diameter achieve their greatest dimensions in rock media.

	CONFIGURATION	SCALED EFFECTIVE DOB	REMARKS
A		DOB=0	1. Standard surface emplacement for purposes of calculation only. 2. <u>NOT</u> recommended for field use.
B		$DOB = \frac{t}{3W^{0.3}}$	1. Munition case resting on ground surface. 2. "t" must equal 1.5m (5 feet) or more. 3. Subtract "t" from calculated crater depth.
C		$DOB = \frac{Z}{W^{0.3}}$	1. Standard subsurface emplacement. 2. If casing is used to line shaft, casing must be withdrawn $(15/W^{0.3})$ meters from munition.
D		$DOB = \frac{Z}{3W^{0.3}}$	1. Do not use in hard rock.
	DETAIL 1 	Same as for Configuration C or D, as applicable	1. This detail shows maximum internal dimensions for a structure built to protect the munition when depths of burial shown in paragraph 3-5d are exceeded. 2. $y \leq 0.5$ meters 3. $\frac{d}{c} \leq 1.5$

NOTE: A minimum of 1.5 meters (5 feet) of tamping or stemming should be placed over any ADM whenever possible.

★ Figure 6-4.1. Emplacement configurations.

★6-10. True Crater Characteristics

a. *General.* The true crater is defined as the boundary between the fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The characteristics of the true crater are of primary interest to the engineer when considering military applications involving the demolition of hard targets.

b. *True Crater Radius.* The true crater radius is defined as the radius of the circle that best describes the intersection of the preshot ground surface with the walls of the true crater. For depths of burst less than optimum, the true crater radius and the apparent crater radius are approximately equal.

c. *True Crater Depth.* The expansion of the high-pressure gases generated by a nuclear explosion in soil or rock produces a cavity surrounding the detonation. The depth of the true crater is equal to the depth of burst of the ADM plus the radius of the cavity created by the detonation. The ultimate cavity size depends on the growth rate of the cavity, the propagation velocity of the stress wave produced by the detonation, the depth of burst, and the yield of the ADM. In the range of yields and depths of burst of interest to the military engineer, the cavity radius is approximately equal to—

$$\begin{aligned} R_c &= 45 W^{1/3} \text{ feet} \\ &\text{or} \\ &14 W^{1/3} \text{ meters} \\ R_c &= \text{cavity radius} \\ W &= \text{device yield in kilotons} \end{aligned}$$

The true crater depth, therefore, may be determined from the equation:

$$\begin{aligned} H_T &= DOB + R_c = DOB \text{ feet} + 45 W^{1/3} \text{ feet} \\ H_T &= \text{true crater depth} \\ DOB &= \text{depth of burst} \end{aligned}$$

d. *Shape of True Crater.*

- (1) The shape of the true crater varies with depth of burial. The true crater

profile for depths of burst up to 15 $W^{0.3}$ meters (50 $W^{0.3}$ feet) is approximately parabolic.

- (2) For depths of burst greater than 15 $W^{0.3}$ meters, the outline of the cavity becomes discernible and the sides of the true crater approach a conical configuration.
- (3) The true crater shape of subsidence craters is approximated by a cylinder of radius 10 percent greater than the cavity radius and a depth slightly greater than the depth of burial.

e. *True Crater Lip.* The lip of the true crater is formed from the upward displacement of the ground surface arising from the expansion of the cavity formed by the energy released from the device. The amount of displacement that occurs is dependent upon the properties of the soil media, the ADM yield, and depth of burial.

★6-11. Characteristics of Rupture and Plastic Zones

a. *Rupture Zone in Rock Media.* The rupture zone resulting from a cratering detonation in a rock medium extends beyond the true crater boundaries for varying distances depending upon the scaled depth of interest. For shallow or optimum depths of burial directly below the ADM where the confining pressures are high, the rock may be fractured to a distance of 1.5 cavity radii ($1.5 R_c$) from the point of detonation. The sides of the rupture zone in the vicinity of the point of detonation may extend to 3 cavity radii ($3R_c$). The rupture zone at the surface extends approximately 1.5 times the radius of the crater ($1.5 R_A$) from ground zero. Figure 6-5 shows the probable shape and extent of the rupture zone in rock.

b. *Plastic Zone in Rock Media.* Since the fracture and yield stresses in most rock media are almost equal, the plastic zone, if it exists at all, extends only slightly beyond the rupture zone. The boundaries of the plastic zone are roughly parallel to the rupture zone boundaries. In rock media, the plastic zone has essentially the same strength and permeability as the undisturbed rock.

c. Characteristics of Rupture and Plastic Zones in Soil. The extent of the disturbed region resulting from an explosion in soil media is determined primarily by the shearing stresses produced by the detonation. When a soil medium is subjected to shearing stresses greater than the shearing strength of the soil, plastic deformation occurs. Since the material in both the rupture and plastic zones of a soil medium is subjected to permanent deformation as a result of shear failure, it is most difficult to differentiate between the rupture and plastic zones.

★6-11.1. Craters as Obstacles

The effectiveness of a crater as an obstacle

depends primarily on the slope of the crater sides and the properties of the medium cratered. The depth of loose material on the crater sides and the moisture content of the soil become important factors at near critical slopes. Test results indicate that a slope of approximately 30° is critical for tracked vehicles in dry soil (desert alluvium). More gentle slopes may be negotiated by such vehicles without assistance, whereas greater slopes require that some type of assistance be provided. In hard rock, such as basalt or granite, the size of the rubble in the crater may be expected to preclude vehicle passage without regard to the steepness of the slope.

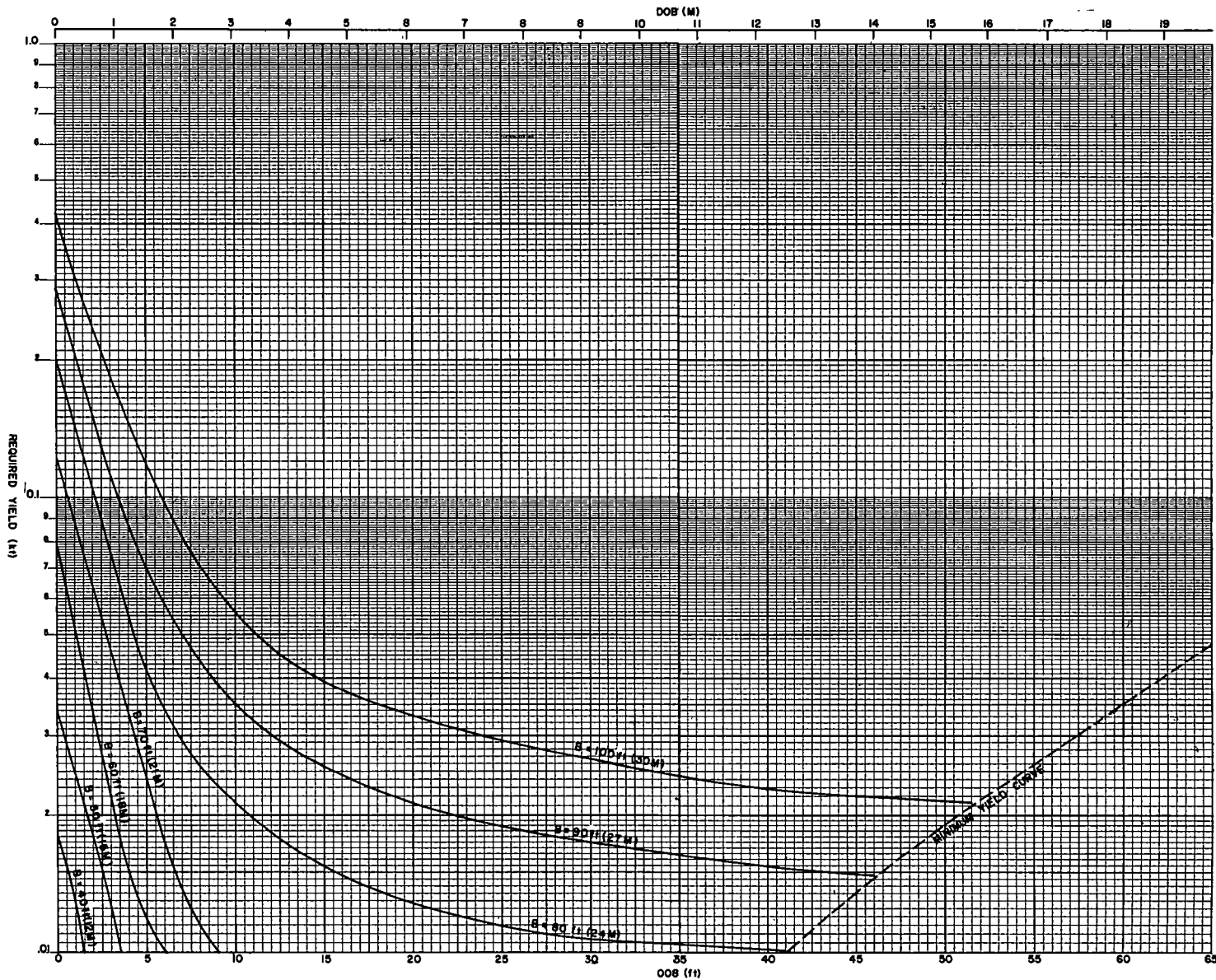


Figure 6-7. Yield selection criteria for cratering fills.

c. *Illustrative Example.* The following example illustrates the recommended procedure for determining ADM yields required to demolish earthfills:

Given: An earthfill with dimensions as given in figure 6-8 is to be destroyed utilizing nuclear explosives. There are three possible emplacement positions: (1) in the culvert at the center of the fill; (2) at a depth 25 feet beneath the crest; and (3) on the crest.

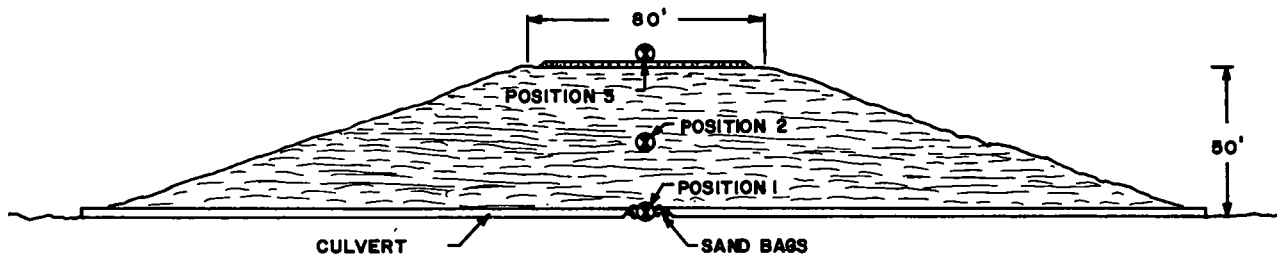
Find: The yield required to demolish the earthfill at each of these positions.

Solution: Position 1 — Emplacement in the Culvert. DOB = 50 feet and width of crest (B) = 80 feet. It is apparent from figure 6-7 that the DOB = 50-foot line does not

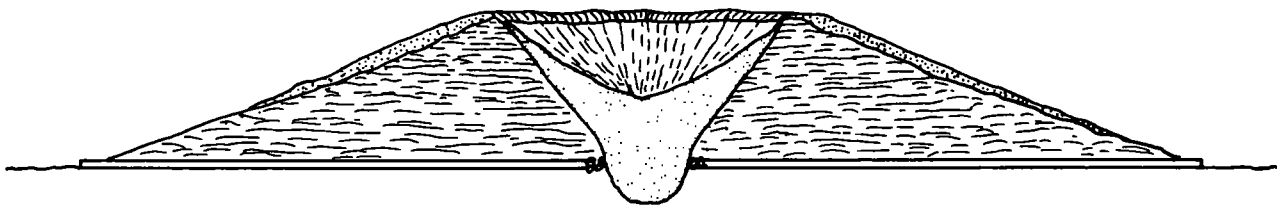
intercept the B = 80-foot curve. The minimum yield, therefore, is determined by moving vertically along the DOB = 50-foot line until the minimum yield curve is intercepted. Reading to the left from the point of interception, the minimum yield is 0.018 kt.

Position 2—Emplacement at DOB = 25 Feet Below Crest. DOB = 25 feet and width of crest (B) = 80 feet. Using figure 6-7, the yield required for DOB = 25 feet and B = 80 feet is .012 kt.

Position 3 — Emplacement on Crest of Fill. DOB = 0 and width of crest (B) = 80 feet. Using figure 6-7 for DOB = 0 and B = 80 feet, the required yield is 0.19 kt.



PRESHOT SKETCH OF EARTH FILL FOR ILLUSTRATIVE EXAMPLE



POSTSHOT SKETCH OF EARTH FILL FOR ILLUSTRATIVE EXAMPLE, POSITION 1

Figure 6-8. Earthfill for illustrative example and crater resulting from detonation in position 1.

heaves the slope material outward and slightly upward.

- (2) The device is emplaced at approximately the same elevation as the defile floor as shown in figure 6-10.
- (3) The depth of burst of the device is near optimum for crater radius ($160 \text{ ft/kt}^{0.3}$ or $49 \text{ m/kt}^{0.3}$) measured normal to the slope as indicated in figure 6-10.
- (4) The existing geologic features must be given strong consideration in se-

lecting the ADM yield. Generally it is desirable to select a yield of such a magnitude that the true crater boundary produced by the detonation intercepts any weathered zone or plane of weakness as shown in figure 6-10. The true crater radius required to insure that the true crater boundary intercepts the weathered zone is determined from the geometry of the slope, and the required yield is then calculated.

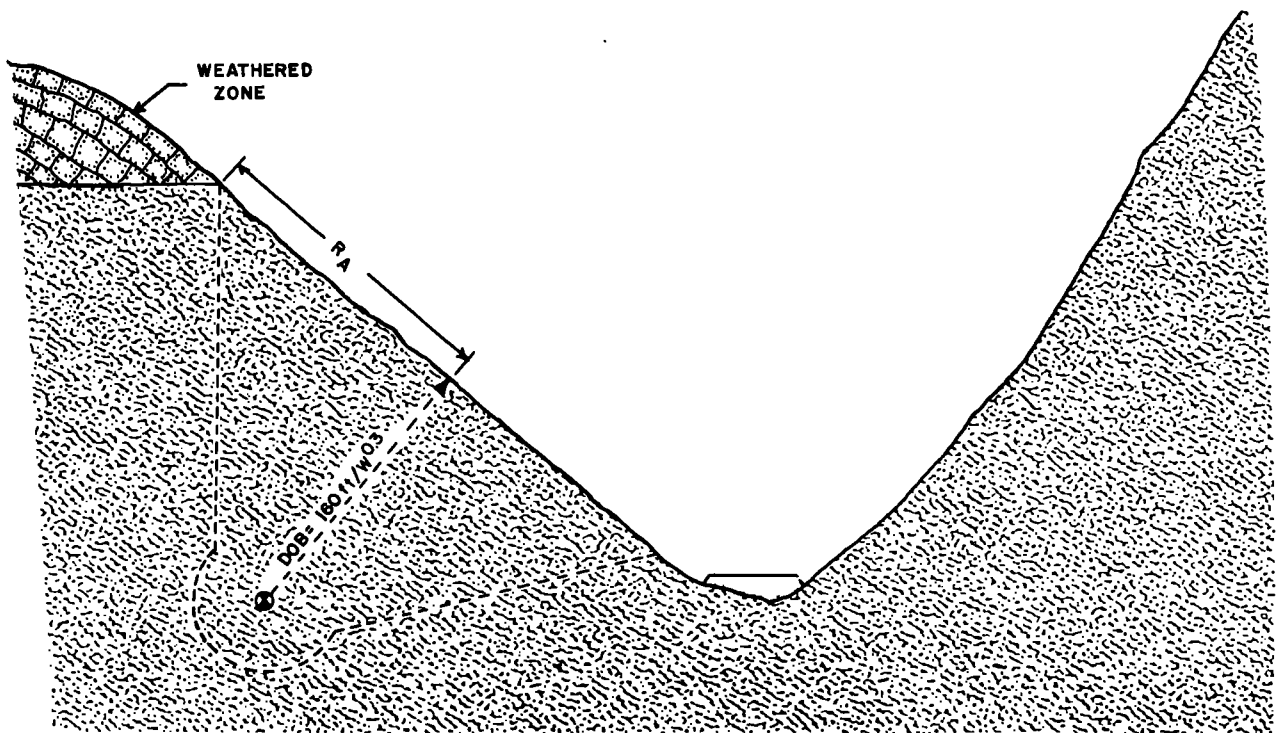


Figure 6-10. Recommended ADM emplacement position for initiation of landslides.

d. Illustrative Example. This example illustrates the procedure for determining the location, yield requirement, and emplacement location for ADM employment to initiate a slide in a defile.

Given: The barrier plan requires the denial of access through the defile shown in figure 6-11.

Find: The location, required yield, and emplacement location for use of an ADM to

create a landslide barrier in the defile.

Solution:

- (1) *Location selection.* After careful reconnaissance of the defile, the site indicated on figure 6-11 is selected for the following reasons:
 - (a) It is located at the narrowest point in the valley floor.
 - (b) The slope of the valley wall is 46° which is greater than the minimum recommended slope for slide initiation.
- (2) *Site description.* A vertical cross section through the selected site is shown in figure 6-12. The valley walls consist of dry soil and soft rock. The weathered zone is located at a vertical distance of 380 feet from the valley floor.
- (3) *Yield selection.* The distance from the valley floor to the weathered zone measured along the slope of valley wall is 600 feet. The true crater radius, therefore, must be at least 300 feet so that the crater boundary intercepts the weathered zone. The radius, considering optimum depth of burial in dry soil for a 1-kt munition, is 175 feet (fig. 6-2).

True crater radius = apparent crater radius (R_A) (para 6-10).

$$r_A = 175 \text{ ft/kt}^{0.3}$$

$$R_A \text{ (required)} = 300 \text{ feet}$$

$$R_A = r_A W_2^{0.3}$$

$$\text{Substituting: } 300 = 175 W_2^{0.3}$$

$$W_2^{0.3} = \frac{300}{175}$$

$$= (1.72)^{3.33}$$

$$= 6 \text{ kt}$$

The closest acceptable ADM yield to 6 kt as given in table 3-1 is—

$$W = 10 \text{ kt}$$

$$R_A = 175 W_2^{0.3} = 175 (10)^{0.3} \\ = 350 \text{ feet.}$$

(4) *Emplacement position.*

- (a) The ADM is emplaced at a scaled depth of 160 feet/kt^{0.3} measured normal to the face of the valley wall to optimize the crater radius.

$$\text{dob} = 160 \text{ ft/kt}^{0.3}$$

$$\text{DOB} = \text{dob } W^{0.3}$$

$$\text{Substituting: DOB} = (160 \text{ ft/kt}^{0.3}) \\ (10 \text{ kt})^{0.3}$$

$$= 160 (1.99) =$$

$$320 \text{ feet.}$$

- (b) The ADM is positioned under the toe of the slope at a distance of 320 feet measured normal to the face of the slope and is placed at approximately the same elevation as the valley floor as shown in figure 6-12. Emplacement of the ADM in this position requires construction of a horizontal emplacement tunnel.
- (5) *Probable cratering and landslide sequence.* Upon detonation, material inside the true crater is moved outward. Some of this material is ejected several hundred feet into the defile. Immediately thereafter, the material above the true crater boundary begins to fail so that a new slope is formed behind the existing one. As the material slides and tumbles downward, the true crater cavity is filled with a portion of the rubble. The remaining material and the *ejecta* from the initial crater forms a barrier across the valley floor. The height of the barrier produced by the detonation depends to a great extent on the manner in which the material behind the existing slope fails and on the steepness of the newly formed slope. Figure 6-13 shows the vertical cross section of the valley as it might exist following the detonation.

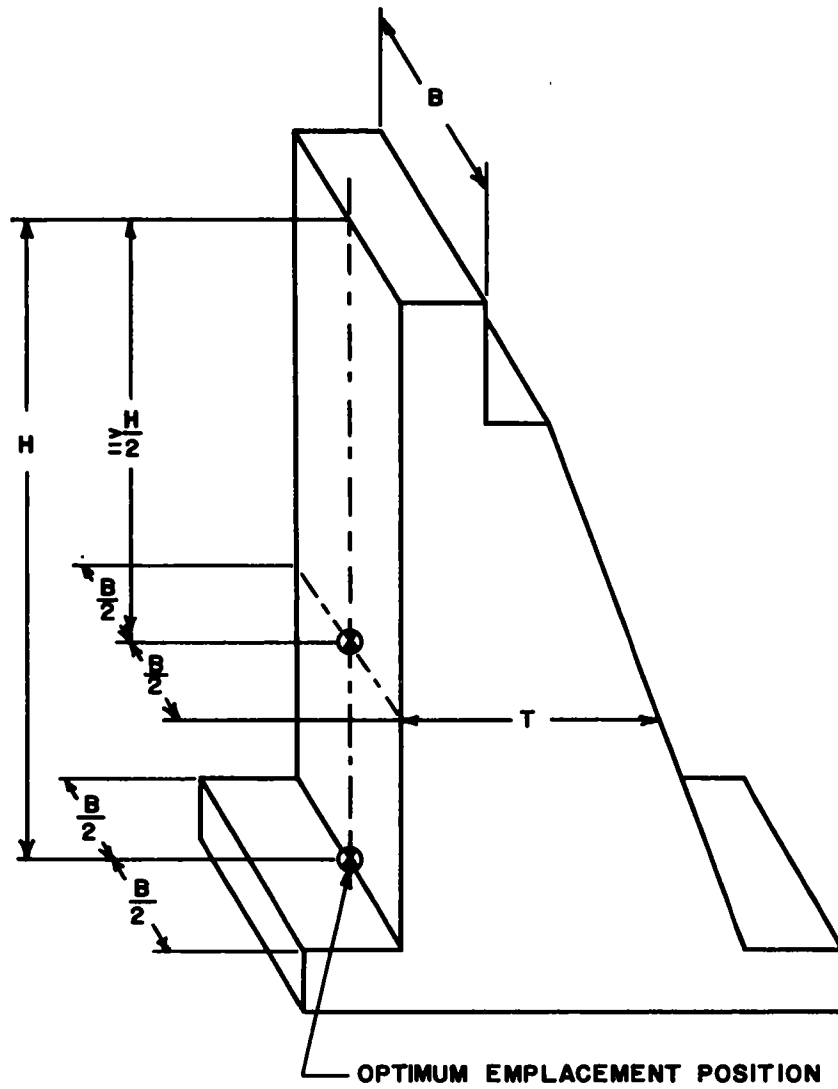


Figure 6-26. ADM emplacement behind bridge abutment.

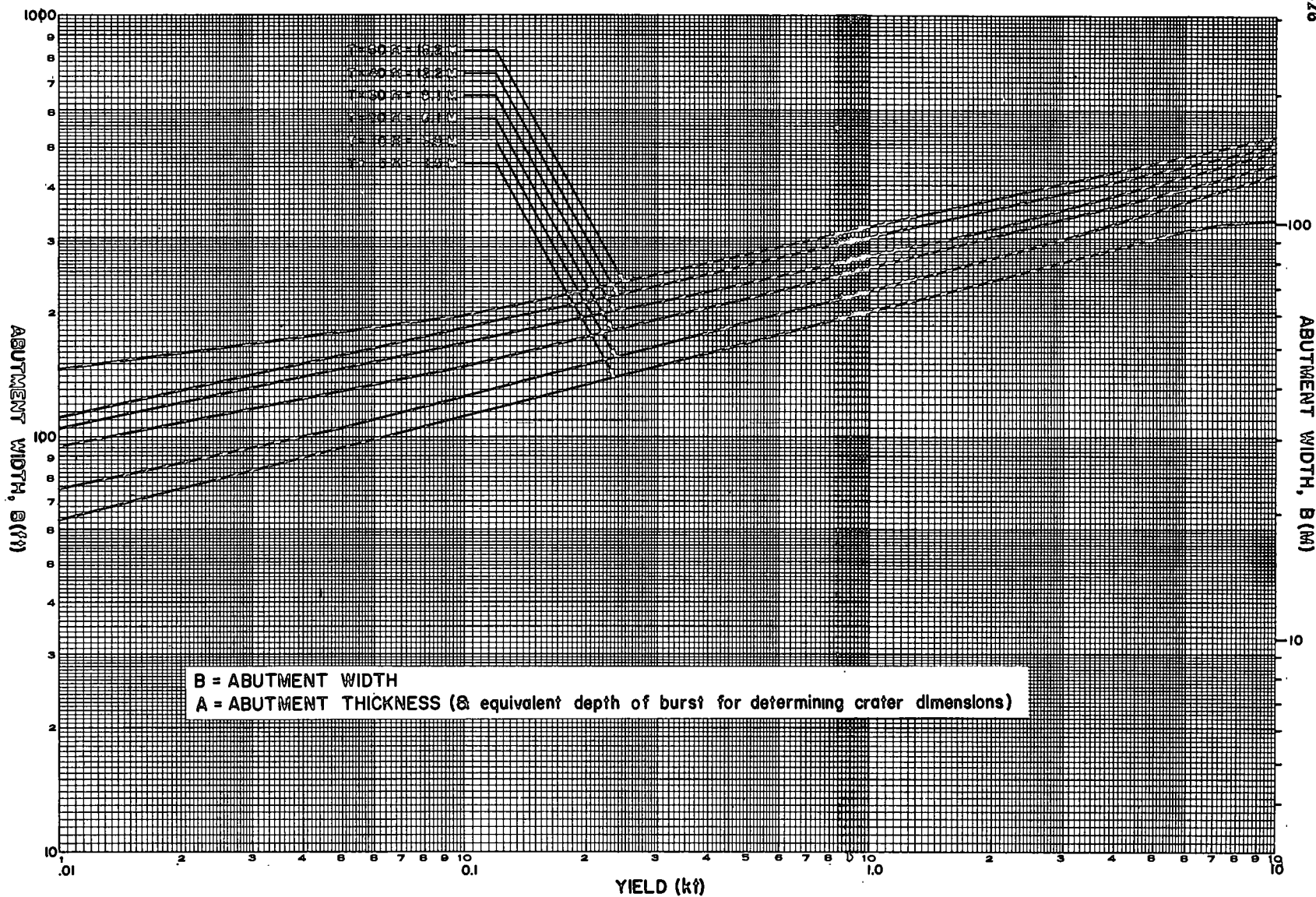


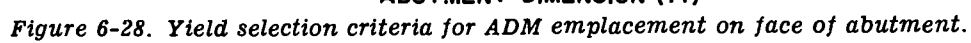
Figure 6-27. Yield selection criteria for device burial behind abutment at depth equal to or greater than $\frac{1}{2} H$.

(2) *Emplacement on face of abutment.*

- (a) If the characteristics of the ADM, the tactical situation, or the non-availability of emplacement construction equipment preclude placing the ADM behind the abutment, the nuclear explosive may be placed on the face of the abutment.
- (b) The detonation of an ADM on the face of an abutment above the water level produces a crater in the abutment similar to the crater resulting from a surface burst in hard rock. If the ADM is placed underwater some increase in crater dimensions is achieved because of the tamping effect of the water, but no attempt is made in the yield selection criteria presented in this manual to numerically evaluate this increase.
- (c) The yield requirements for destruction of an abutment by detonation of an ADM on the face of the abutment are determined by both

the width (B) and the thickness (T) of the abutment. A yield should be selected which produces a true crater diameter plus rupture zone equal to the abutment width and a true depth ($45 W^{1/3}$ feet or $14 W^{1/3}$ meters) equal to the thickness. Figure 6-28 gives curves for determining required yields for abutment destruction. The higher yield determined from the curves for an abutment of given dimensions (B and T) governs.

- (d) If an abutment has a demolition chamber (a chamber specifically incorporated by design to facilitate bridge denial), the ADM is detonated in the chamber. Figure 6-28 is used to select the required yield. The thickness of the abutment is considered to be the horizontal distance from the center of the ADM emplaced inside the chamber to the face of the wall adjacent to the backfill.



b. Demolition of Bridge Pier.

- (1) The best ADM emplacement position for pier demolition is at the base of the pier. If the device cannot be placed at the base of the pier, it is placed at a distance from the top of the pier—preferably one-half the pier height ($\frac{1}{2} H$)—to destroy a major portion of the pier.
- (2) Selection of a yield to destroy a pier depends on the width (B) of the pier. The combined effects of spall, va-

porization, crushing, and plastic deformation will breach the pier thickness (T) if an ADM is used which is of sufficient yield to breach the width of the pier. Figure 6-30 gives the curve for determining the yield requirements for pier demolition. The curve is based on a determination of the yield which produces a true crater diameter plus rupture zone in hard rock equal to the width of the pier.

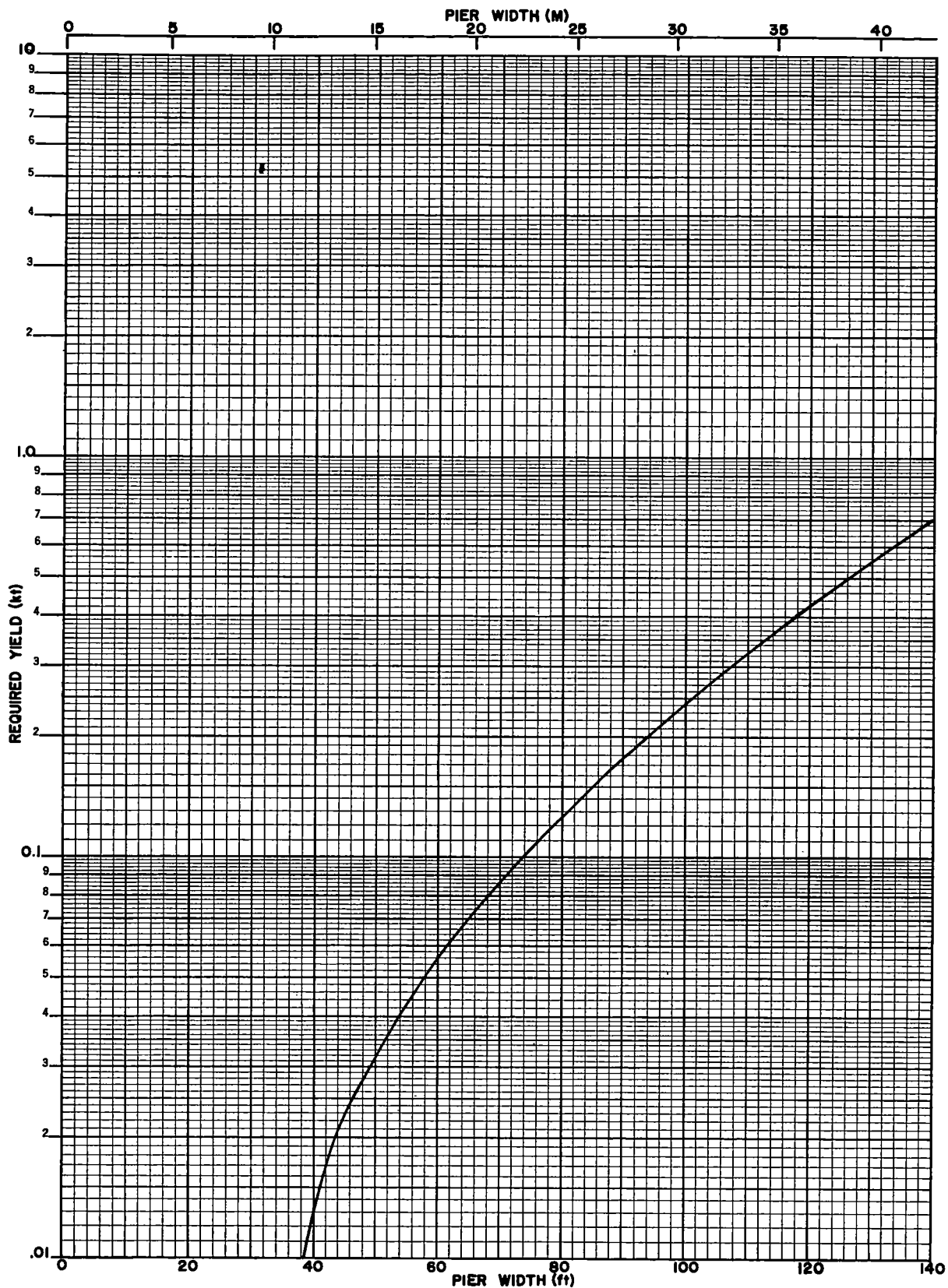


Figure 6-30. Yield selection criteria for emplacement on face of pier; top of pier or abutment; or traveled way.

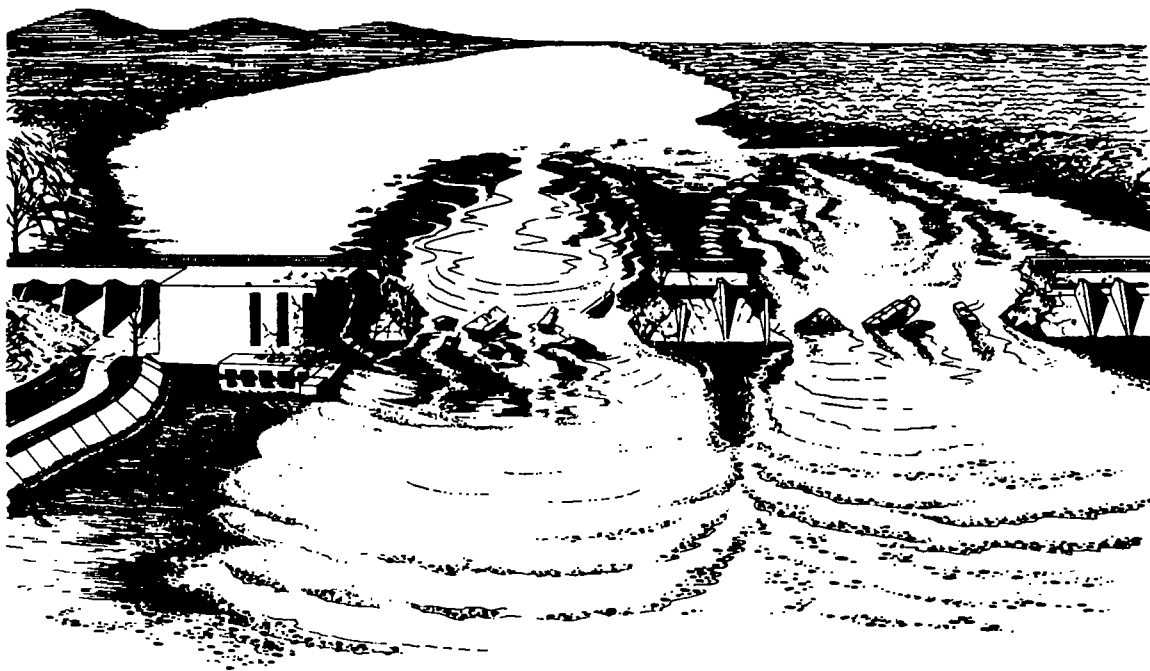
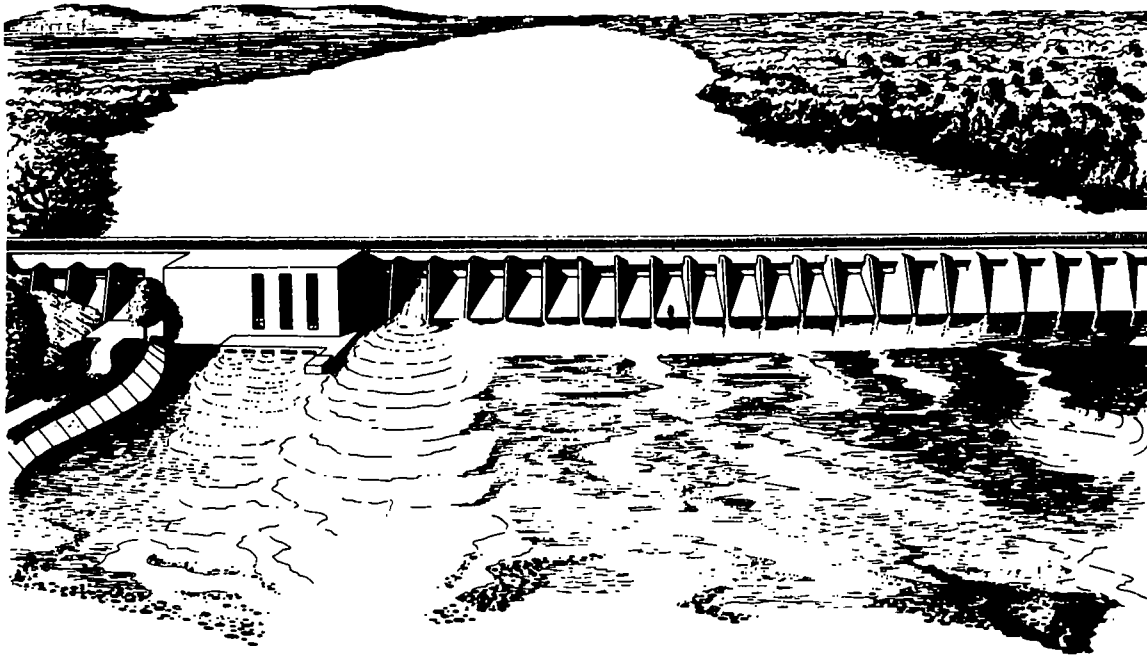


Figure 6-36. Before and after views of a gravity dam subjected to multiple nuclear explosions.

6-24. Gravity Dams

a. Gravity dams (fig. 6-37) constructed of concrete or masonry have massive cross sections and often rise to heights of 400 feet or more. Because of the volume of material to be

shattered, gravity dams are best breached by placement of the ADM in an inspection gallery. If more than one gallery exists, the one which is lowest and nearest to the upstream heel of the structure is selected.

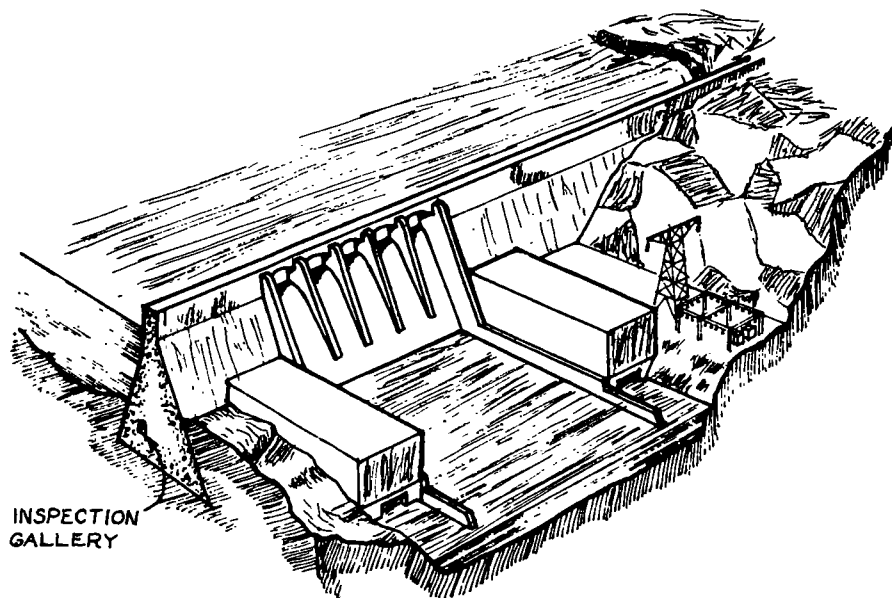


Figure 6-37. Gravity dam.

b. A method for determining the yield required to breach a gravity dam is presented for the following emplacement locations (fig. 6-38):

- (1) In an inspection gallery.
- (2) On the upstream face of the dam at a water depth at least twice the distance to be breached or 50 feet (15 meters), whichever is the smaller, to insure efficient coupling of the energy from the ADM into the concrete.
- (3) On the downstream face of the dam below the water level.

c. Yield selection curves for breaching concrete gravity dams are given in figure 6-39. The yield selection criteria are based on breaching the distance to the downstream face

primarily by the spall mechanism and breaching the distance to the upstream face by the cavity and rupture zone formed around the ADM. If the ADM is emplaced in an inspection gallery (position 1), the yields required for breaching the distance to the *upstream face* should be determined separately by using the appropriate curves in figure 6-39 (curves a and b); the *larger* of the two breaching yields is the governing yield for demolition of the dam. If the ADM is placed on the upstream face (position 2), it is only necessary to determine the yield required to breach the distance to the downstream face (curve a). If, on the other hand, the ADM is placed on the downstream face (position 3), it is only necessary to determine the yield required to breach the distance to the upstream face (curve c).

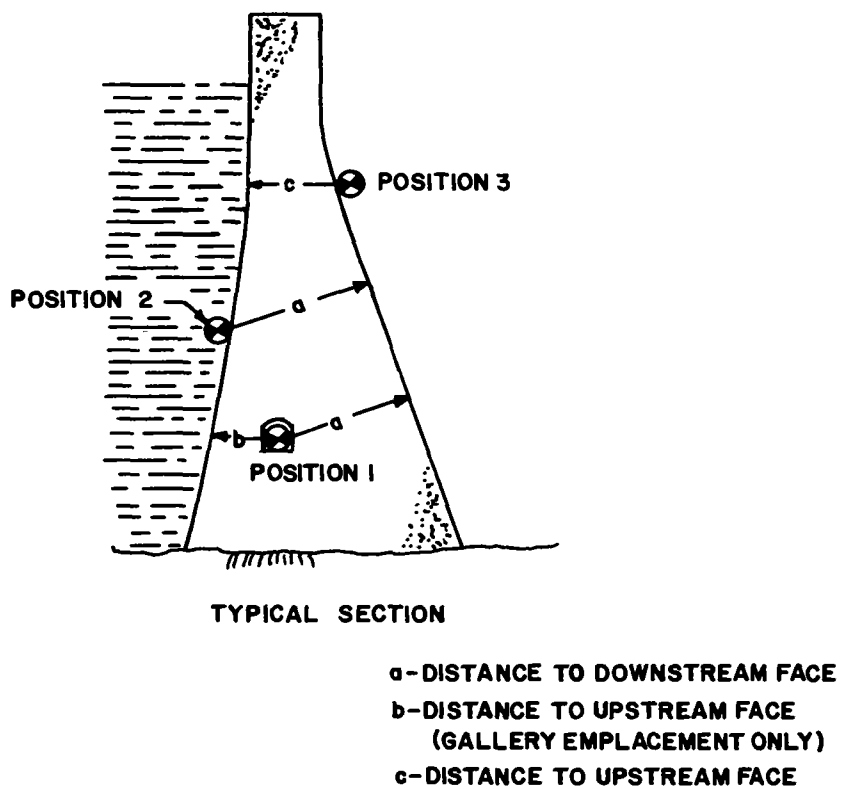


Figure 6-38. ADM emplacement for concrete gravity dam demolition.

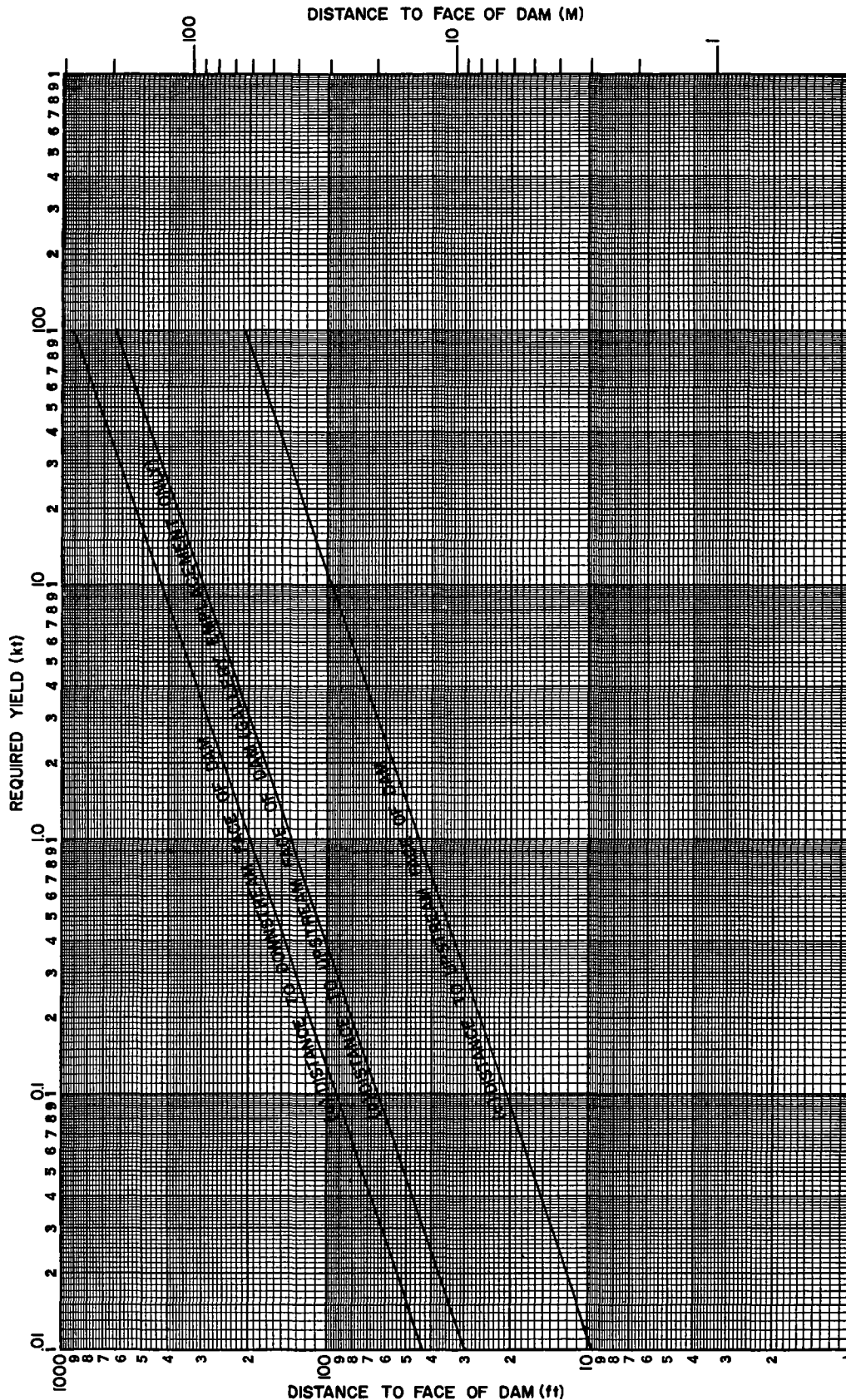


Figure 6-39. Yield selection criteria for concrete dam demolition.

d. Illustrative Example. The following example illustrates the procedure for selecting yields required to destroy concrete gravity dams for various emplacement locations.

Given: One of several strategic targets being considered for destruction is the dam shown in figure 6-40 with dimensions as indicated.

Find: The ADM yield required to breach the dam for the following emplacement positions the inspection gallery, on the upstream face, 50 feet below the water level; and on the downstream face, 100 feet below the top of the dam.

Solution: *Position 1—Emplacement in Inspection Gallery.* The distance to the upstream face of the dam is 50 feet and to the downstream face of the dam is 85 feet. Referring to figure 6-39 for the distance to the upstream face (curve b), the yield required is 0.05 kt; and for the distance to the downstream face (curve a), the yield required is 0.08 kt.

Answer: Yield required to breach the distance from inspection gallery to downstream face

of dam is the critical (larger) yield, and the ADM to be used must be equal to or greater than 0.08 kt.

Position 2—Emplacement on Upstream Face of Dam. The ADM is emplaced on the upstream face 50 feet below the reservoir water level or 100 feet from the top of the dam as shown. With the device in this position, the distance to the downstream face is 60 feet. Referring to figure 6-39 (curve a), the required yield is 0.026 kt.

Answer: ADM yield to be used must be equal to or greater than 0.026 kt.

Position 3 — Emplacement on Downstream Face of Dam. The ADM is placed on downstream face of dam, 50 feet below the water level or 100 feet below top of dam as shown. With the ADM in this position, the distance to the upstream face is 66 feet. Referring to figure 6-39 (curve c), the required yield is 3.4 kt.

Answer: ADM yield to be used must be equal to or greater than 3.4 kt.

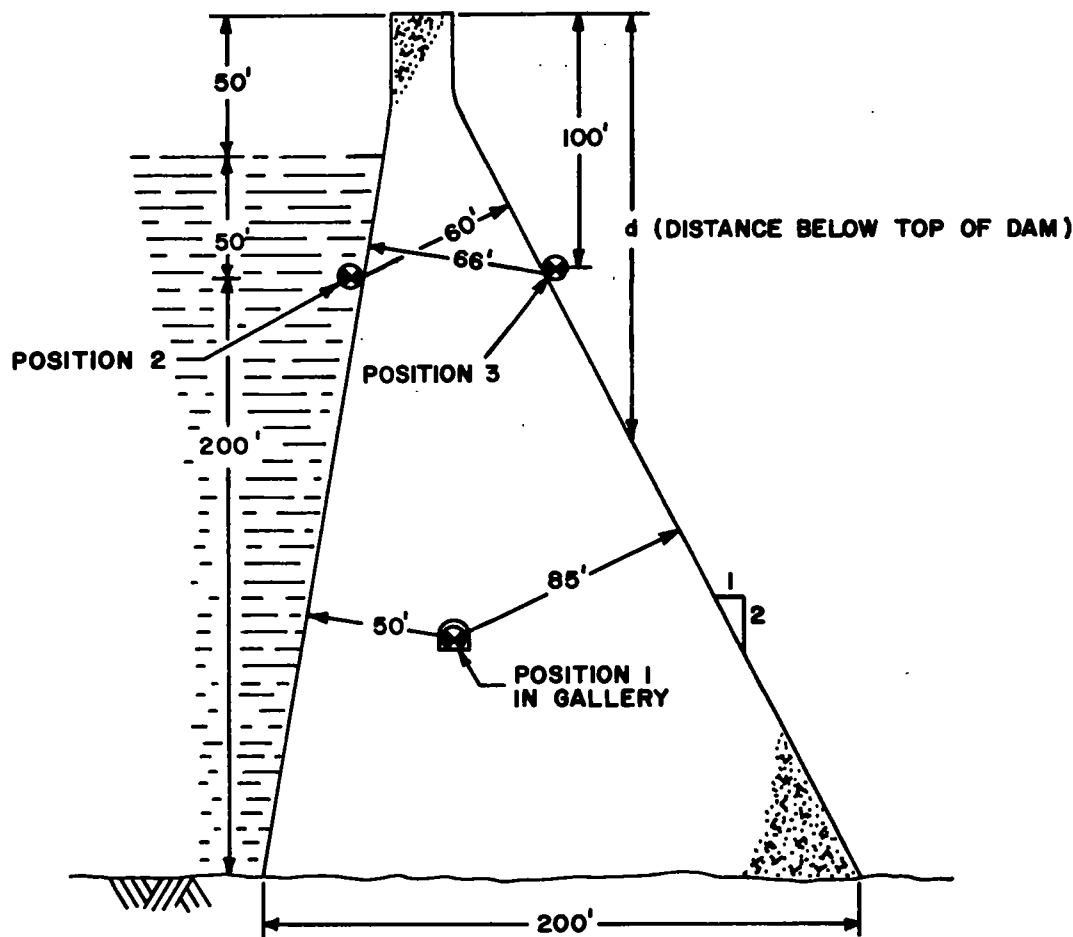


Figure 6-40. Concrete gravity dam for illustrative example.

6-25. Arch Dams

a. *Arch dams* (fig. 6-41) are usually thin, relatively short, and comparatively high. They are constructed of masonry or concrete usually in V-shaped gorges. The thinness of the cross section allows a smaller yield ADM to be used than is required for the more massive gravity dams. The inspection gallery inside the structure is again the best site for the placement of an ADM; however, the galleries may not be easily accessible, and smaller dams may have no galleries at all. Placement in

the reservoir on the upstream face of the structure at least 50 feet (15 meters) below the water level also produces excellent results in such instances. Because of the thin cross section, even placement of an ADM on the downstream face of the structure generally gives satisfactory results with relatively small yields. Furthermore, the stability of an arch dam is dependent upon the arch abutments; for this reason, the dam is also vulnerable to collapse from demolition of its abutments.

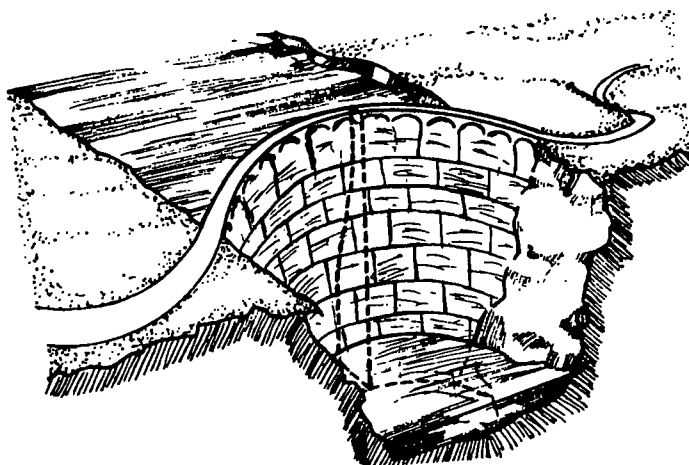


Figure 6-41. Arch dam.

b. Figure 6-39 is used to compute the required yield for breach of an arch dam. The computation is accomplished in the same manner as described for gravity dams in paragraph 6-24.

c. The strength of this type dam lies in its arch construction. Any appreciable weakening of the arch permits the hydrostatic pressure exerted by the deep water behind the dam to cause failure of the entire structure.

d. *Illustrative Example.* The following example illustrates the recommended procedure for selecting yields required to destroy concrete arch dams for various emplacement configurations.

Given: An arch dam, with dimensions as shown in figure 6-42, is to be destroyed.

Find: The yields required for the following emplacement positions as indicated in figure 6-42: ADM emplaced in inspection gallery; ADM emplaced on upstream face; and ADM emplaced on downstream face.

Solution: *Position 1—Emplacement in Inspection Gallery.* The distance to the upstream face is 27 feet and to the downstream face of the dam is 54 feet. Referring to figure

6-38 (curve b), the required yield is less than 0.01 kt; and for downstream distance, the required yield is 0.02 kt.

Answer: Yield required to breach the distance from the inspection gallery to upstream face of the dam is the critical yield (larger) and must be equal to or greater than 0.02 kt.

Position 2—Emplacement on Upstream Face of Dam. The ADM is emplaced on the upstream face 100 feet below the reservoir water level. With the ADM in this position, the distance to the downstream face is 44 feet. Referring to figure 6-39 (curve a) the required yield is .011 kt.

Answer: ADM yield to be used must, therefore, be equal to or greater than .011 kt.

Position 3 — Emplacement on Downstream Face of Dam. The ADM is placed on downstream face of dam at the base of the dam as shown. With the ADM in this position, the distance to the upstream face is 88 feet. Referring to figure 6-39 (curve c) the required yield is 7.5 kt.

Answer: ADM yield to be used must, therefore, be equal to or greater than 7.5 kt.

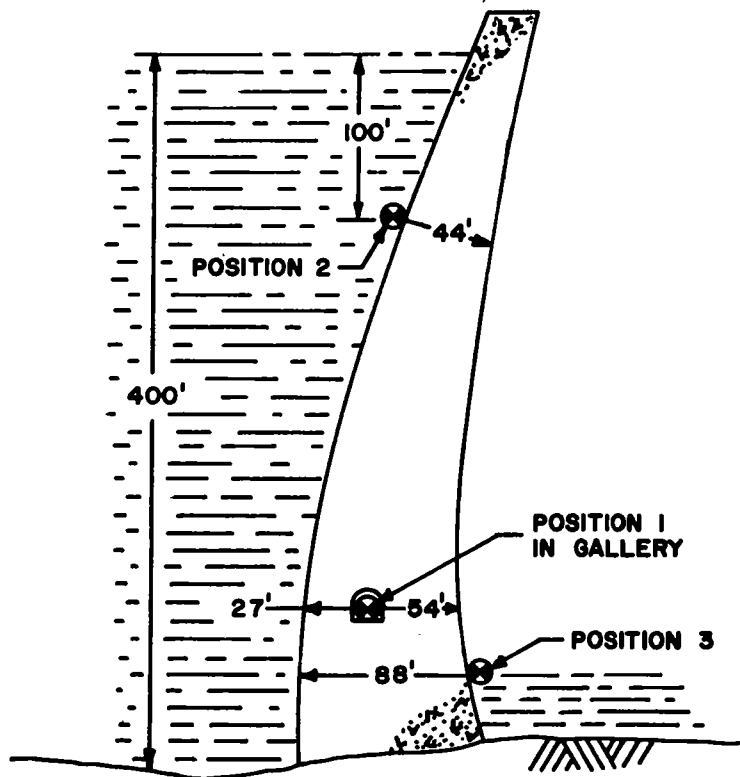


Figure 6-42. Concrete arch dam emplacement positions for illustrative example.

6-26. Buttress Dams

a. *Hollow buttressed dams* (fig. 6-43) usually consist of a series of parallel, equidistant, concrete buttresses covered by a watertight, sloping upstream face. The downstream face of hollow buttressed dams and those on foundations susceptible to erosion are closed in to provide spillway facilities. All the structural elements of the buttress dam are constructed of reinforced concrete and are generally thinner than the structural components of either arch or gravity dams. By destroying a buttress, at least two spans of the dam will collapse. The two emplacement positions which will be discussed are: placement below the water level on the upstream face of the dam, and placement in contact with the buttress itself. If the buttress dam has a closed-in

downstream spillway, the ADM may also be placed at a buttress location in the inspection shaft which runs through the buttress parallel to the main axis of the dam (fig. 6-44).

b. *Yield selection* for the destruction of buttress dams depends primarily on the extent of damage desired since the majority of the structural components are comparatively thin and therefore easily breached. If the intent is solely to release the impounded water, the upstream slab supported by the buttresses is easily breached. The required ADM yield (positions 1 and 2) may be determined from figure 6-39 for emplacement on the upstream face (curve a) or for emplacement on the downstream face of the slab (curve c). The same mechanisms considered in analyzing

creased yield or deeper depth of burial must be tried. This method is valid only in those cases where the ADM is emplaced on or beneath the center of the crest. Should emplacement be made on the upstream face with the

view of inducing structural failure, the analysis is reduced to a visual inspection of post-shot conditions to ascertain if the damage is adequate.

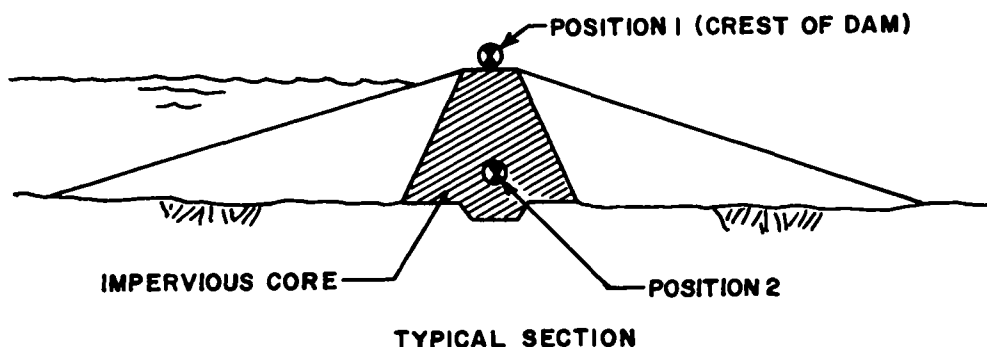


Figure 6-46. Typical earth dam and ADM emplacement positions.

d. Illustrative Example. The following example illustrates the recommended procedure for selecting yields required to destroy earth dams.

Given: The dam shown in figure 6-47 is scheduled for demolition. Two ADM have been allocated, a BRAVO/1 kt and DELTA/5 kt. Fallout is not to be considered a limiting factor; also, emplacement capabilities permit ADM burial to a depth of 30 feet.

Find: The yield and emplacement position required to destroy the dam.

Solution:

- (1) The lower yield (1 kt) and the least difficult emplacement position (on the crest) is considered first.
- (2) The D_A for a surface burst from appendix II for a 1-kt ADM is 40 meters (131 feet); the R_A , therefore, equals 65 feet. The true depth is calculated

as follows: $H_T = DOB + 45 W^{0.3} = 0 + 45 (1) = 45$ feet.

- (3) Plotting these values to scale and then connecting the R_A and H_T plots, it is found that the initial breach occurs approximately at the water level and is inadequate.
- (4) Rather than go to the next higher yield in view of the known burial capability, another trial at a $DOB = 15$ feet is repeated. The R_A at a $DOB = 15$ feet is found to be 108 feet (fig. 6-2) and the $H_T = 15 + 45 = 60$ feet. The increase in values of R_A and H_T due to burial is shown with a broken line. The initial breach is now 15 feet which meets the criteria for destruction of earth dams.

Answer: Therefore, the ADM recommended is the BRAVO/1 kt emplaced 15 feet below the center of the crest.

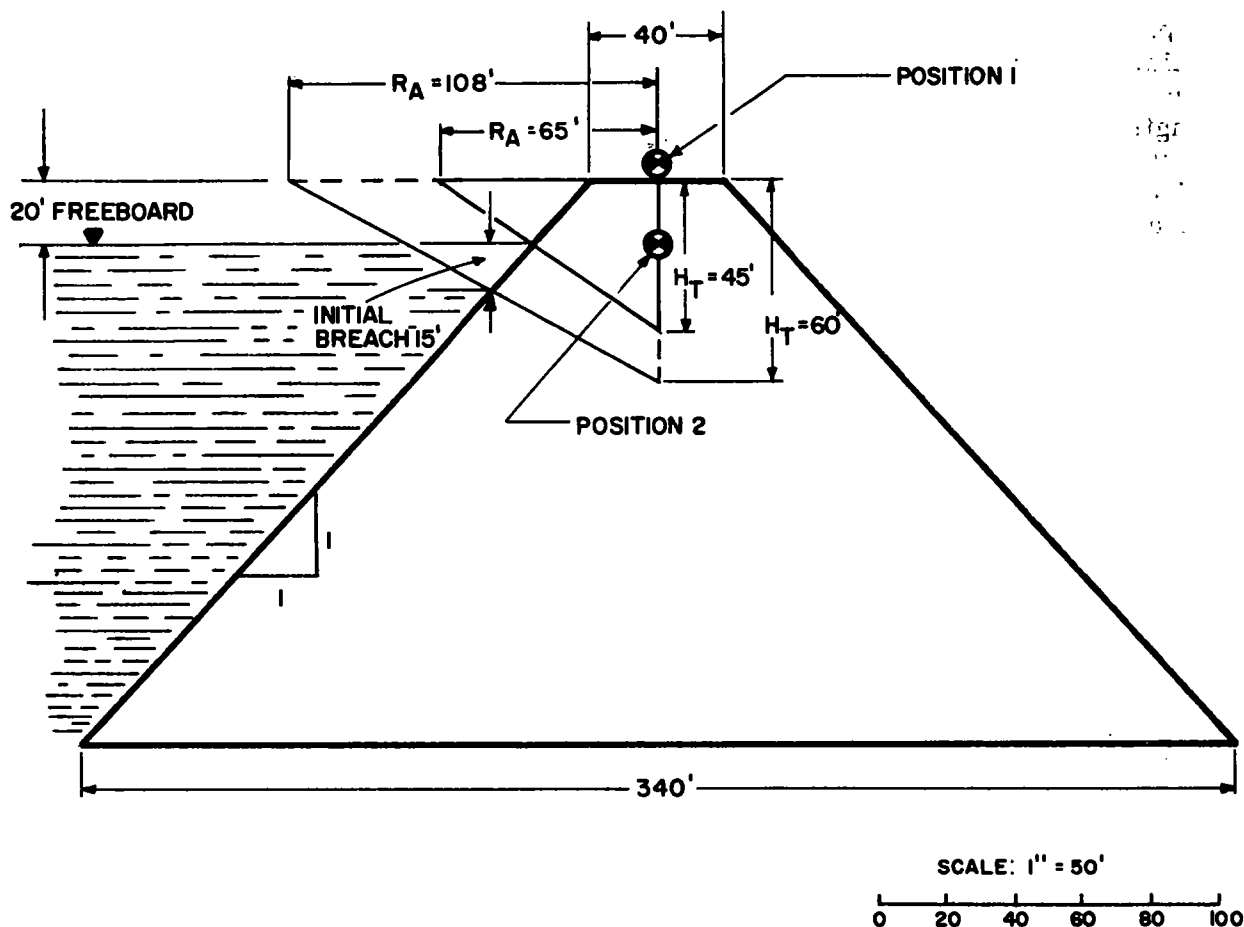


Figure 6-47. Graphical solution to earth dam illustrative problem.

6-28. Emplacement Upstream From Dam

The breaches achieved with ADM placed at the previously discussed locations are produced primarily by the cratering effect of the blast. A nuclear detonation upstream, so that the dam is outside the cratering radius, can also cause failure by the action of the hydrostatic pressure and shock waves generated by the detonation. This effect may result in the overturning, sliding, or cracking of the structure. See TM 23-200 regarding the effect of blast and shock on dams.

6-29. Gate Blowout

a. An important function in the operation of any dam is the regulation of flow over or through the structure. In most cases, this is accomplished by flood (spillway) gates (fig. 6-48) which regulate flow over the top of the structure and sluice gates which control the flow in tunnels through the dam. Some dams have only one type of outlet while others have both.

b. The strength of *sluice* gates has been found to be such that any nuclear detonation

6-30. Downstream Flood

a. In any plan for destruction of a dam, one of the important considerations is the magnitude of the resulting flood. Many factors combine to determine the size and destructiveness of such a flood. It is beyond the scope of this manual to provide a detailed system of analysis for flood prediction. If the extent of such a flood must be estimated accurately, the actual conditions at and below the dam should be analyzed by a military hydrologist.

b. A rough estimate of the magnitude of the flood may be obtained by assessing the following factors:

- (1) *Quantity (acre-feet) of water available (the amount of water available at any given time in a reservoir).* If the primary purpose of the dam is for electric power generation, the water level is kept as high as possible to extract the maximum energy from the falling water. On the other hand, if the dam is for flood control, the reservoir is normally kept as empty as possible to provide the maximum catch basin. Reservoir levels behind dams used for water regulation vary widely depending on the interplay of water input and demand.
- (2) *Gap (or weir) created.* The size of the breach blown in the dam determines how quickly the water is released. As indicated earlier, arch dams will probably undergo complete

and sudden failure, thus approximating the ideal case which is sudden and complete disappearance of the dam. Gravity dams do not fail in this fashion; rather, a breach causes water to run out gradually. As indicated earlier, erosion plays a large part in breaching earthfill dams — even a small initial breach may be rapidly expanded by the water itself. If a sudden release of the maximum amount of water is desired from a gravity or earthfill dam, a larger yield or multiple burst is required.

- (3) *Topography.* The shape and slope of the downstream river basin strongly affects the speed and depth of the released water. A large open plain dissipates the energy of the water and diminishes the height of the flood crest. Conversely, a narrow, steep gorge coupled with decreasing flood elevation accelerates the water and keeps the depth peaked for maximum destruction. Upstream topography is also important since it determines how quickly the stored water can be delivered to the dam site.
- (4) *Initial head.* The initial acceleration of the water is determined by the height through which it initially falls as the dam is breached. A high dam provides a much greater “wall of water” than a low dam. Moreover, the velocity which the released water attains significantly influences the damage created downstream.

Section V. CANALS

6-31. General

a. Canals vary considerably in complexity. At one extreme is the single level canal, dug through an area only slightly above sea level and requiring no locks or lifts; at the other extreme is the canal which must raise ships over a terrain barrier. These multi-level canals employ systems of locks and gates, storage reservoirs, and pumps.

b. As a rule, the more complicated the system, the easier it is to put it out of operation and the more difficult to repair. Because of the differences in size and construction of canals, however, no specific directions for demolition applicable to all cases are possible. Each target must be analyzed individually to determine its vulnerable points.

c. Inland waterways and their auxiliary fa-

cilities are subect primarily to the effects of blast, cratering, hydrostatic pressure, and ground shock. In the selection and placement of an ADM for the disruption of an inland navigation system, the governing effect is determined; and an ADM of approximate yield is selected.

d. Nuclear detonations are very effective when properly employed; however, there are occasions when conventional explosives can be used more efficiently or when nuclear detonations would cause an undesirable level of damage. Thus, a detailed analysis of the canal system is necessary to insure that available munitions are employed effectively and that undesired damage is avoided.

6-32. Single Level Canals

The single level canal is the most difficult to put out of operation. Its relatively invulnerability lies in its simplicity. It is a ditch connecting two natural bodies of water. Its water supply is inexhaustible, and no mechanism is required to regulate the waterflow. The only practicable way to put a single level canal out of service is to block it. This may be accomplished with varying degrees of success by earthslides or ships.

a. *Blocking With Earthslide.* Blocking a canal with an earthslide is possible only in rare circumstances. The optimum conditions demand a soil with low cohesive strength and a relatively steep bank, high enough to leave a sufficient volume of earth after the blast to form a canal-blocking slide. Because cuts for canals are usually designed expressly with slide prevention in mind, the occurrence of these conditions is infrequent. Nevertheless, cratering data as discussed in paragraph 6-3 through 6-14 regarding the creation of landslides are also applicable to canals.

b. *Use of Block Ships.* The sinking of ships in a canal in an effective, expedient means of blocking. Conventional explosives or other means of scuttling are normally used for this purpose.

6-33. Variable Level Canals

a. The variable level canal, as a rule, cannot be considered as a single feature distinct

from its surroundings. It is more likely a part of a larger system which exploits one or more watersheds. In addition to providing navigable waterways, such a system may involve power generation, water conservation, flood control, irrigation, and fish migration. Disruption of the facilities which permit navigation on such a system is likely to affect all the other functions as well.

b. If it is desirable to damage only the navigational facilities and to leave the remainder of a system intact, extreme care is necessary when employing ADM against specific targets.

(1) *Dams.* In planning denial of a navigational system, the basic mission must be borne in mind. If it is desired to achieve the greatest possible damage, destruction of the dam which impounds the water for the system may be more profitable than an attack on the lock facilities that allow vessels to bypass the dam. Destruction of the dam not only prevents navigation—even with all its other facilities intact—but puts an end to power generation, irrigation, and flood control. Additional damage may be done by the release of the impounded water. If the dam is to be the target, the data and methods presented in paragraph 6-23 through 6-30 are used.

(2) *Locks.* A lock is the most common system for raising or lowering vessels. To pass a vessel headed downstream, the lower gate is closed; and by means of a system of valves and ducts, the lock chamber is filled with water. The vessel enters the chamber and the upper gate is closed behind it. Through additional valves and ducts, the water is drained out of the chamber to the lower level of the canal. The lower gate is then opened and the vessel can proceed. The lower gate must be the full height of the chamber; the upper gate need extend only from the highest water level to a safe margin below the deepest

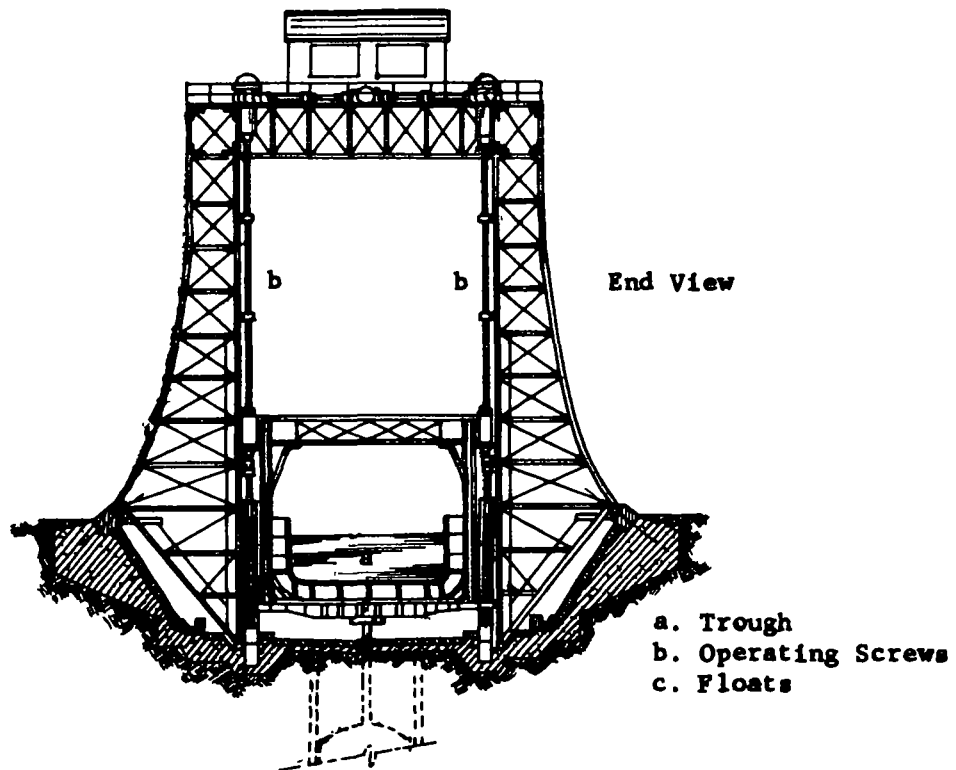
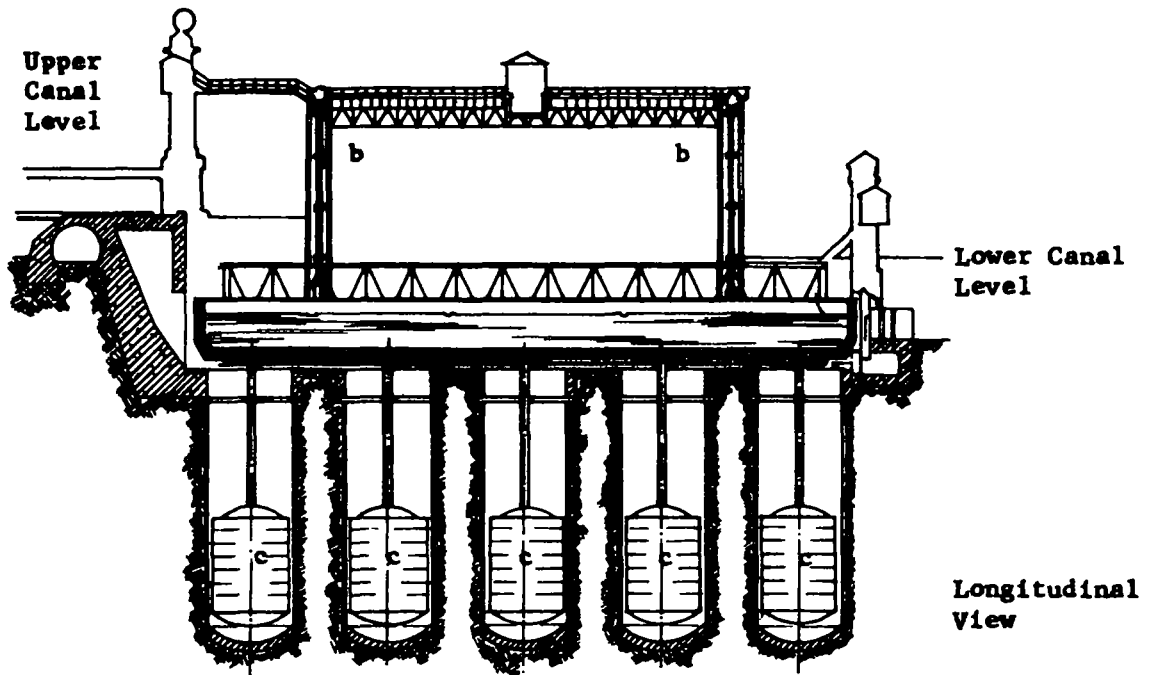


Figure 6-51. Example of vertical lift.

(4) Pumps.

- (a) Water generally flows through a lock system by gravity, and pumps are not essential to the operation. In areas where water is scarce, water may be returned to a storage reservoir or to another lock by pumping rather than released to flow downstream. Destruction of the pumps in such a system decreases its capability by preventing the conservation of the water but does not completely prevent the use of the locks.
- (b) When there is no natural water supply and the entire canal system is artificial, the pumps are vital.
- (c) An ADM of any size will temporarily disrupt the operation of a pumping station by destroying the building, controls, powerlines, and other facilities; however, the items most difficult to replace are the pumps themselves. In a large

pumping station, the pumps may be distributed over an area so large that one munition of reasonable yield will not cause the required damage to them all. In such a case, conventional demolition charges applied to each pump are more efficient and practical.

- (5) *Channels.* When a canal is above the surface of the adjoining ground, it may be drained by blowing out one of the embankments in the same manner as breaching an earthfill dam (para 6-27).
- (6) *Aqueducts.* Canals are particularly vulnerable where they cross roads, valleys, or other waterways on aqueducts. An aqueduct is nothing more than a bridge which carries water, thus destruction of an aqueduct is performed in the same manner as that of any bridge of similar construction (paras 6-15 through 6-22).

Section VI. TUNNELS

6-34. General

This section is provided for the analyst interested in the destruction of or damage to underground or underwater tunnels using ADM. Curves, illustrations, and technical data have been provided so that reasonable estimates of yields and damage may be made.

6-35. Description of Damage

Tunnel damage is classified into four decreasing degrees of damage called zones 1, 2, 3, and 4. Figure 6-52 shows a typical damage profile from a subsurface burst (not in the tunnel) with damage zones and damage radii labeled. Tunnel damage is described as follows:

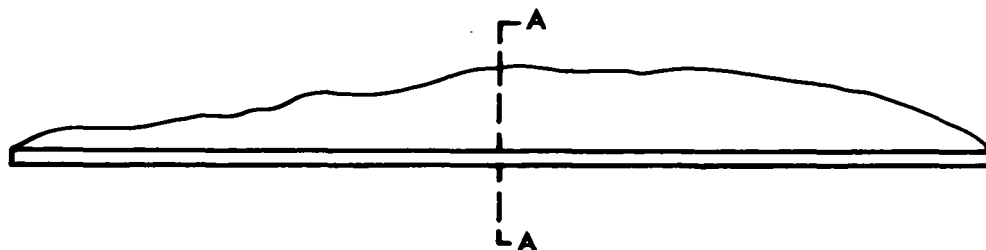
a. Zone 1: Complete Damage. Rock is completely crushed to a radius defined by the compressive strength of the rock. Beyond the area of complete crushing, rock is propelled from all sides of the tunnel causing complete

closure. In this zone, a damage profile does not exist. The outer limit of zone 1 marks the end of the damage profile.

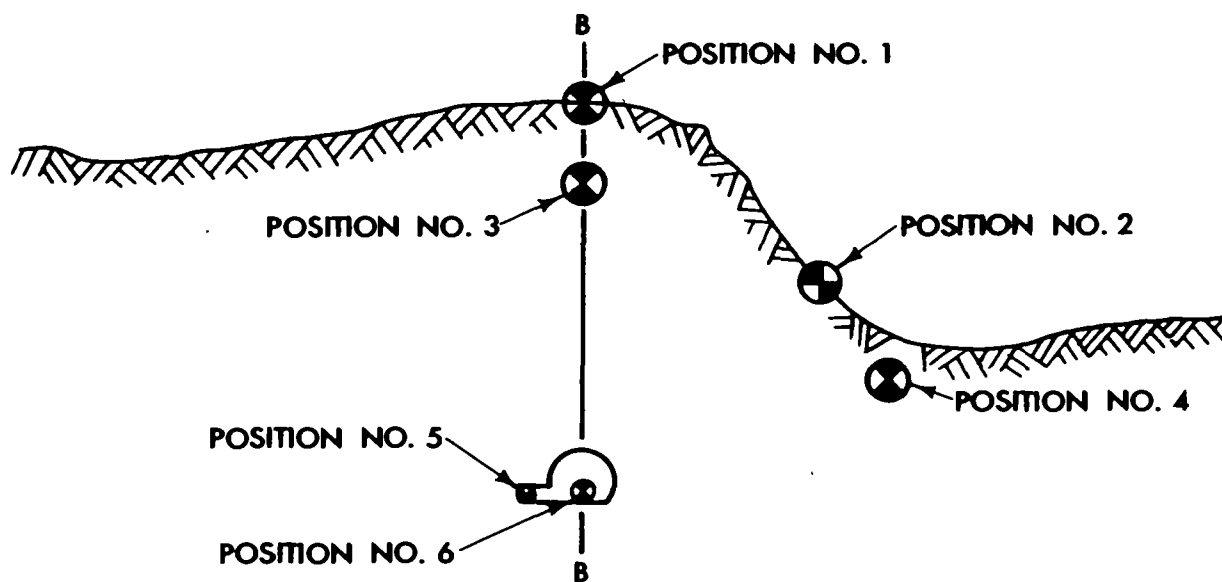
b. Zone 2: Rock Breakage (fig. 6-53). Rock breakage is continuous and increases in thickness nearer to the detonation. Sizeable amounts of rock are broken, and the pieces are large and block-like. The point of closure occurs within this zone where broken rock completely fills the tunnel. Under certain conditions, the extremely high temperatures and pressures may squeeze the surrounding rock into a solid mass.

c. Zone 3: Continuous Slabbing (fig. 6-54). Rock breakage is continuous and relatively uniform in thickness; it is principally on the side toward the detonation. Zone 3 ends where rock breakage and the damage profile becomes continuous.

d. Zone 4: Discontinuous Damage (fig. 6-55). Rock breakage is irregular and inter-



a. LONGITUDINAL PROFILE ALONG B-B



b. SECTION A-A

Figure 6-57. Typical emplacement positions.

6-38. Types of Burst

a. Surface Burst. Radii of the various zones of damage are given in figure 6-58 as a function of yield.

b. Underground Burst. For purposes of tunnel destruction, an underground burst is defined as one occurring at a point below the ground surface but not in the tunnel. Damage radii from an underground burst increases with depth of burial until a depth is reached at which all the mechanical energy released by the burst is translated into ground shock (fully coupled). The tamping and coupling effect that results from a subsurface burst increases damage radii. For depths of burst between 0 and $160 W^{0.3}$ feet ($49 W^{0.3}$ meters), the surface burst damage radii (fig. 6-58) must be multiplied by the coupling factors obtained from figure 6-59 to arrive at damage radii for underground bursts. This multiplication has been incorporated into figure 6-60 which gives

zone 1 damage radii as a function of yield for varying depths of burial. Radii for other damage zones can be obtained from figure 6-61 with the yield. Translation of damage radii to horizontal damage distance within the tunnel is accomplished through use of the nomograph presented in figure 6-62. To be fully coupled, the emplacement must be far enough from the tunnel to prevent the explosion from venting into the tunnel before the cavity reaches its maximum size. This maximum cavity radius is presently estimated at $45 W^{1/3}$ feet ($14^{1/3}$ meters) in soil. To increase the probability of achieving full coupling, a safety factor of 50 percent is added. This results in a minimum burst to tunnel distance of $65 W^{1/3}$ feet ($20 W^{1/3}$ meters). Figure 6-63 shows the optimum condition of emplacement which is at least $160 W^{0.3}$ feet ($49 W^{0.3}$ meters) from the surface and $65 W^{1/3}$ feet ($20 W^{1/3}$ meters) from the tunnel.

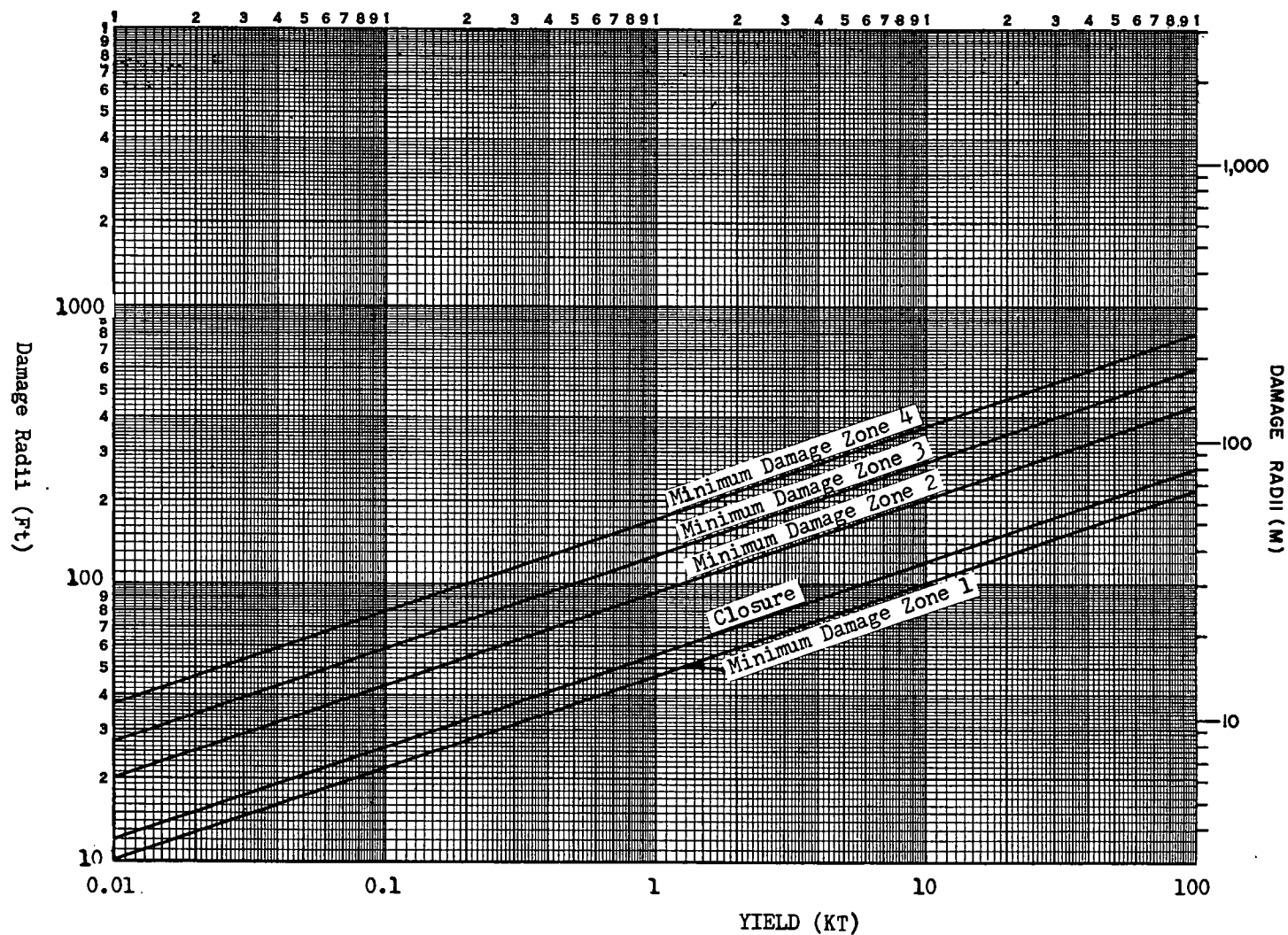


Figure 6-58. Yield versus damage radii to unlined tunnels in rock for a surface burst.

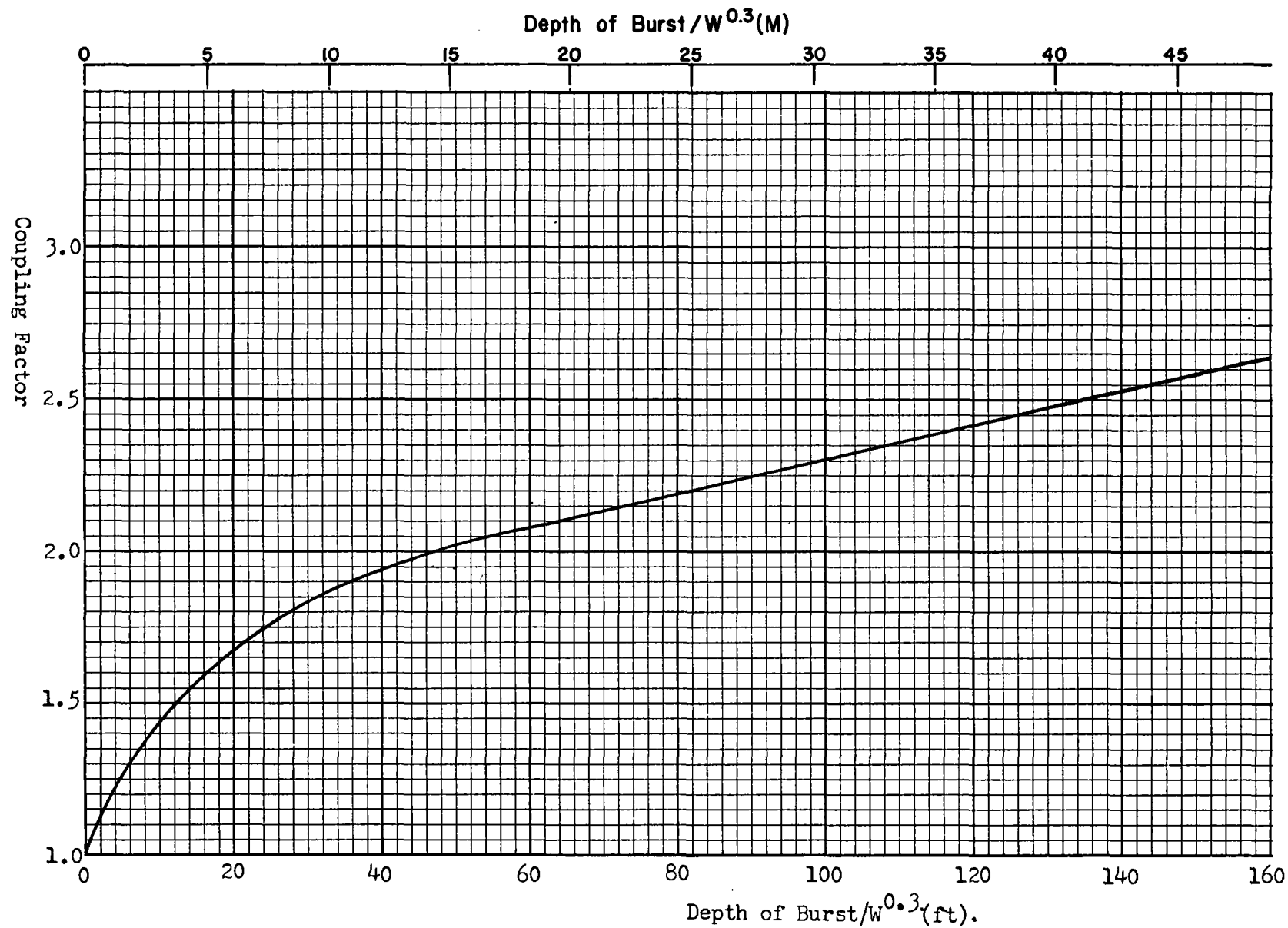


Figure 6-59. Depth of burst versus coupling factor.

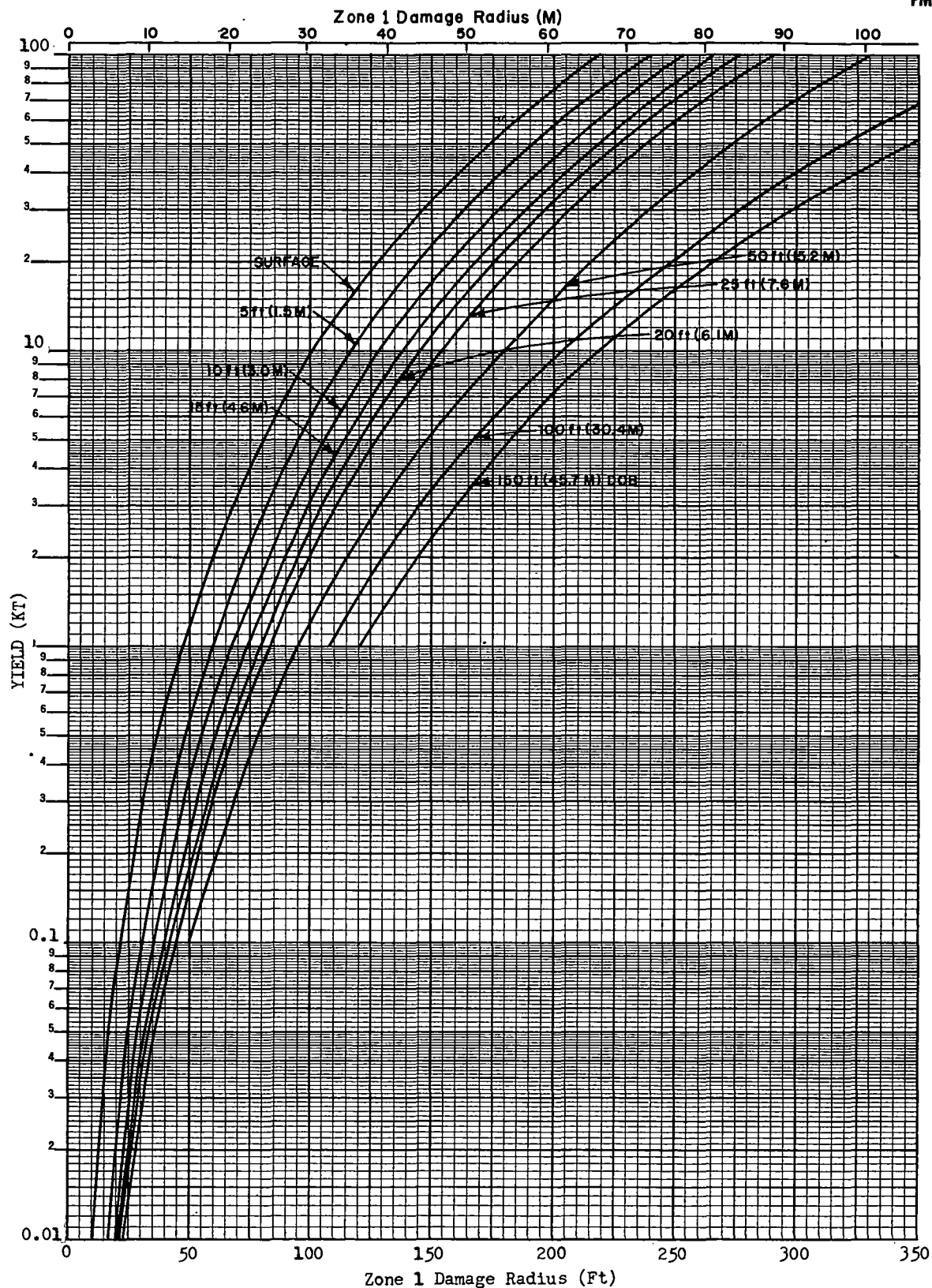


Figure 6-60. Yield versus zone 1 damage radii.

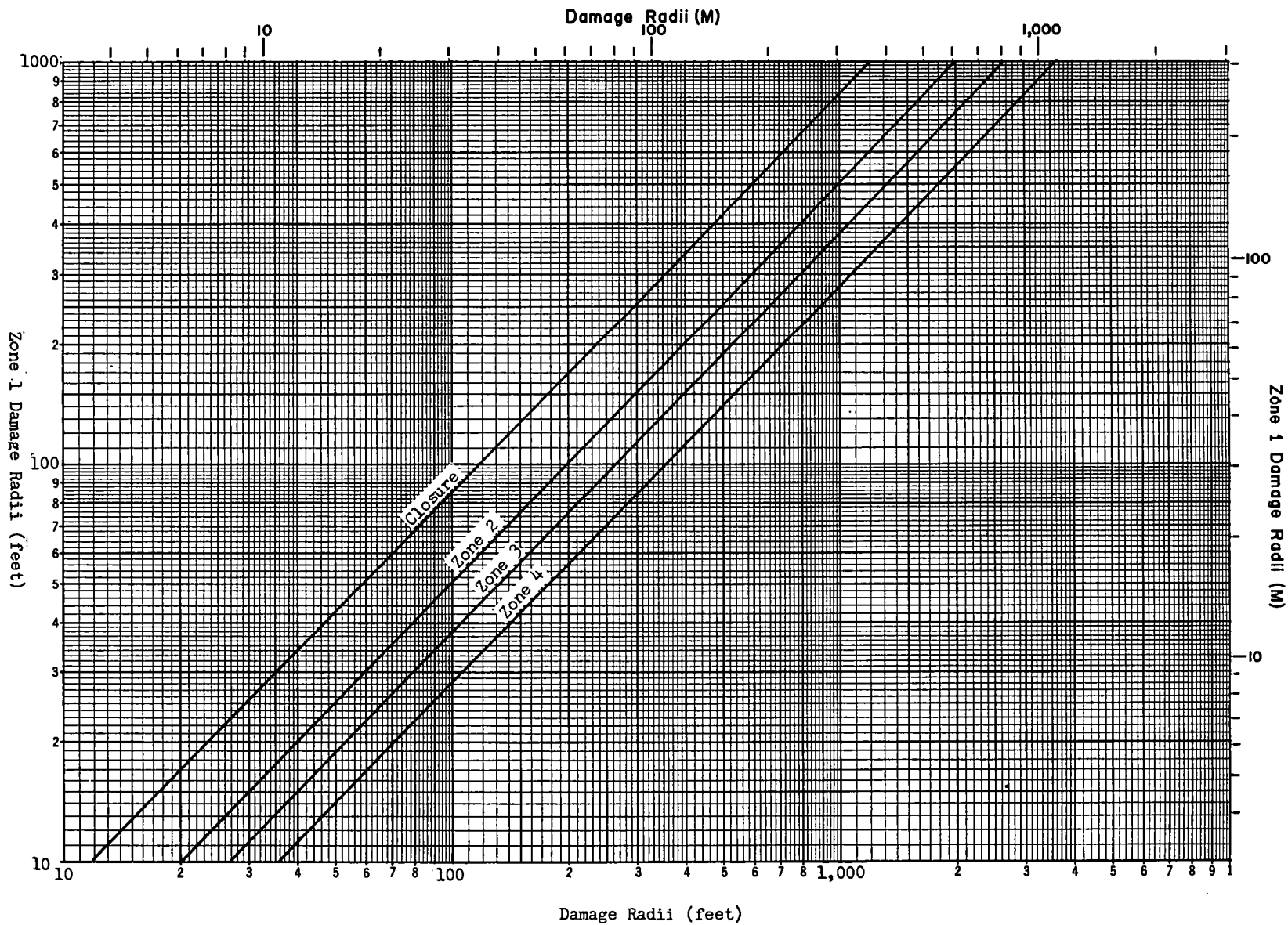


Figure 6-61. Damage radii relationship.

6-39. Factors Affecting Damage for Bursts not in Tunnel

a. Types of Media. The type of media through which the tunnel is bored affects the damage radii to some extent; however, scaled distances for contained shots in tuff and in granite are so close that correction is not warranted.

b. Tunnel Lining. Observed data do not indicate that normal tunnel linings appreciably affect damage; therefore, the data for unlined tunnels are used for all tunnels.

6-40. Burst Offset From Tunnel

ADM may be emplaced in shafts (adits) leading off from the tunnel. In such cases, the damage zones discussed previously for surface and underground bursts cannot presently be determined from data available. Minimum damage can be estimated, however, from the dimensions of an apparent crater in hard rock by equating the offset distance to the DOB. The limit of damage along the tunnel floor is estimated as being equal to that of the rupture zone (1.5 times crater radius). The apparent crater is smaller than estimated since a portion of the material which is normally blown out to form the crater is retained by the tunnel walls and becomes part of the radioactive debris. Emplacement procedures should include complete stemming of the emplacement shaft with at least 2 feet of sandbags or similar material.

6-41. Burst on Tunnel Floor

The damage caused by a nuclear explosion in an open tunnel has not been adequately determined; however, the minimum damage from a burst on the floor of a tunnel can be estimated in the same manner as outlined in the preceding case for tunnel offset emplacement using a zero DOB. Emplacement procedure on the tunnel floor includes the placing of sandbags over the ADM to provide tamping.

6-42. Residual Radiation

a. In Tunnel. At present, no method of estimating the intensity and duration of the

residual activity in a tunnel damaged as a result of a nuclear explosion has been developed.

b. Fallout. The surface and underground detonation of ADM can cause militarily significant fallout. The intensities and extent of contamination are dependent on yield, the depth at which the ADM is buried, and the degree of venting if detonated within a tunnel.

6-43. Post-Explosion Rock Temperature

Under certain conditions, the temperature of the rock in the immediate vicinity of the explosion can reach extremely high temperatures. This temperature rapidly subsides to the boiling point of water but may remain at that temperature for weeks.

6-44. Damage Criteria

a. Severe Damage. Severe damage is defined as that which requires standard tunneling procedures for rehabilitation or tunnel relocation. This is achieved through the use of surface or underground bursts (fig. 6-57; positions 1, 2, 3, and 4). The limit of zone 2 damage is the limit of severe damage.

b. Moderate Damage. Moderate damage is defined as that which requires significant rehabilitation effort but does not call for standard tunneling procedures. However, these latter procedures may be necessary if the tunnel was originally driven through other than homogeneous rock. This level of damage is most easily achieved through use of tunnel offset or tunnel floor bursts (fig. 6-57; positions 5 and 6).

6-45. Yield Determination

The first step in yield determination is the selection of the point at which the ADM is to be placed. Where possible, placement is far enough from the tunnel portals so that the limit of zone 4 damage is contained within the tunnel. If the tunnel length is insufficient, emplacement is at the midpoint. Additional damage may be achieved if the tunnel passes through a fault zone or similar nonstable geological conditions.

a. Surface Bursts. Yield determination for surface bursts (fig. 6-57; position 1 and 2) is

accomplished by determining the burst to tunnel distance and equating this distance to the radius of required zone 1 damage. This provides maximum severe damage while economizing on the required yield. Enter figure 6-60 with this distance, read up to the surface curve, and over to the required yield.

b. Underground Bursts (fig. 6-57; positions 3 and 4). After selection of point on the surface at which the emplacement shaft is to be dug or within a suitable air shaft, the next step is to determine how deep available equipment and/or facilities enable the charge to be placed. Next, calculate the burst to tunnel

distance or required zone 1 damage radius. Finally, enter figure 6-60 with zone 1 radius, read up to depth of burial, and over to required yield.

c. Offset Bursts (fig. 6-57; position 5). Yield determination is made by entering figure 6-64 with the offset distance of emplacement, reading over to the curve and down to yield.

d. Bursts on Tunnel Floor (fig. 6-57; position 6). Enter figure 6-64 with zero offset distance and read yield of 0.186 kt. For this emplacement mode, this yield is constant unless the damage criterion is changed.

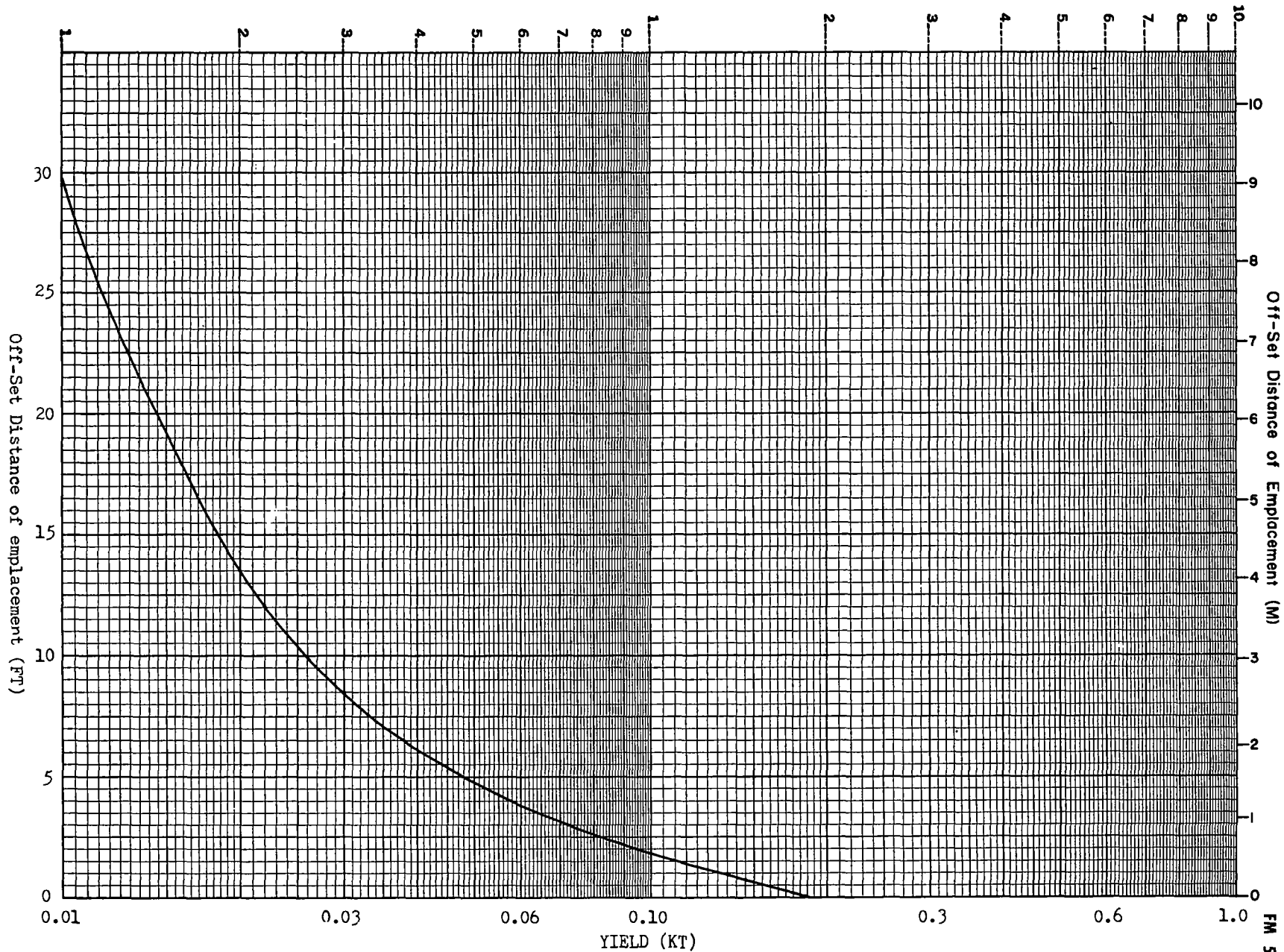


Figure 6-64. Offset distance of emplacement versus yield to block 100 feet (30 meters) of tunnel.

6-46. Illustrative Examples

a. *Surface Emplacement Directly Over Tunnel* (fig. 6-65).

Given: Burst to tunnel distance—100 feet.

Find:

- (1) Minimum yield required to maximize zone 2 damage.
- (2) Determine length of tunnel receiving at least moderate damage (extent of zone 3 damage).

Solution:

- (1) *Minimum yield required to achieve desired damage.* Enter figure 6-60 with zone 1 radius (burst to tunnel distance) of 100 feet, read up to sur-

face curve, and over to yield of 10 kt.

- (2) *Length of tunnel receiving at least moderate damage.* Assuming that a 10 kt ADM is available, enter figure 6-61 with zone 1 radius of 100 feet, read over to zone 3 curve (limit of moderate damage), and down to radius of 265 feet. On nomograph in figure 6-62, use a straightedge to connect burst to tunnel distance of 100 feet on scale A and zone 3 radius of 265 feet on scale B. Extension of this line crosses scale C at a horizontal damage distance of 500 feet (151 meters), which is the length of tunnel receiving at least moderate damage.

f. *Emplacement on Tunnel Floor* (fig. 6-70).

Given: Required damage is 100 feet of rupture along tunnel floor.

Find: Required yield.

Solution: Enter figure 6-64 with zero offset distance and read constant yield of 0.186 kt.

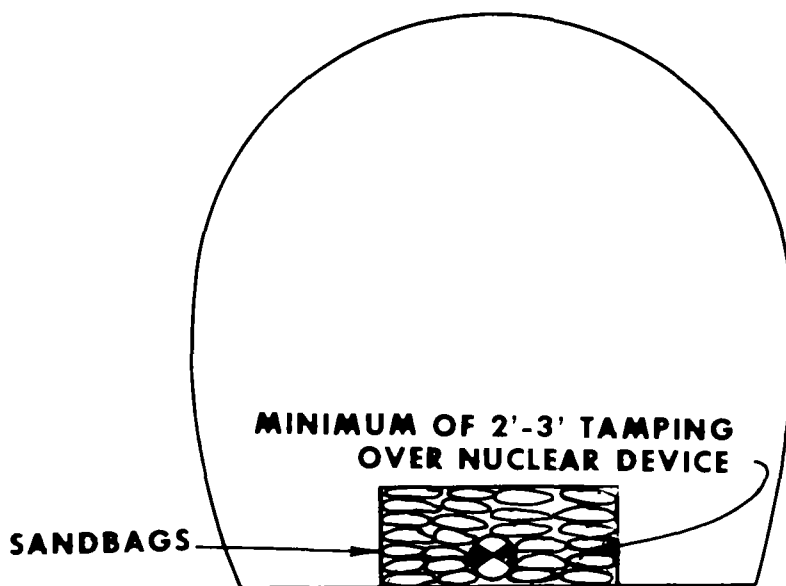


Figure 6-70. Emplacement on tunnel floor.

6-47. Underwater Tunnels

a. *Damage Criterion.* Flooding is the desired level of damage in destruction of an underwater tunnel. In order to achieve flooding, it is necessary to breach the tunnel casing and the overburden to allow the water to force itself into the tunnel.

b. *Placement of ADM.* Two emplacement positions are possible for nuclear demolition of an underwater tunnel. Normally, the ADM is placed in the tunnel against the roof, however, if access to the tunnel is not possible, then the ADM may be emplaced on the river or harbor bottom directly over the tunnel.

c. *Radioactivity.* Radiation resulting from nuclear demolition of underwater tunnels cannot be predicted at present with any degree of

certainty. It is possible that radioactive material will be blown out either end of the tunnel together with fallout and base surge contamination.

6-48. Placement In Tunnel

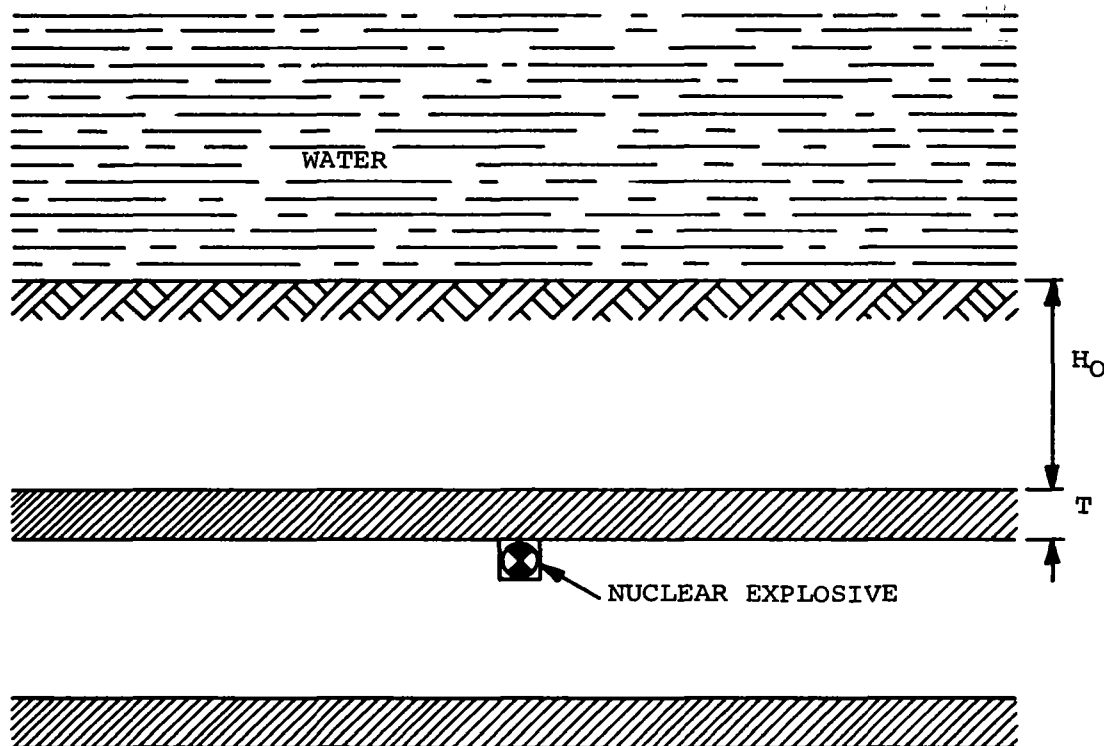
By placing an ADM against the inside top of an underwater tunnel, breaching of the tunnel casing and the overburden is achieved in the same manner as described for an ADM emplaced on the downstream side of a gravity dam.

a. *Rock Overburden.* If the tunnel is under rock, then the tunnel casing, which is usually reinforced concrete, and the overburden can be considered as the same material.

b. *Other Than Rock Overburden.* This term-

inology is used for overburden of all type soils that might be encountered on river or harbor bottoms: sand, clay, silt, muck, or in any combination. Crater dimensions for a given yield in hard rock (concrete) are about one-half those in saturated soils; therefore, it is assumed valid to use one-half the height of overburden ($\frac{1}{2} H_0$) for yield determination where other than rock overburden exists.

c. *Yield Determination.* Figure 6-72 enables rapid determination of required yield by giving the required damage distance as a function of yield. Simply enter with the appropriate distance according to type of overburden, ($H_0 + T$) or $\frac{1}{2} H_0 + T$, then read over to the curve and down to the yield.



$$\text{Required Damage Distance} = H_0 + T$$

Where

H_0 = Height of Overburden

T = Thickness of Tunnel Casing

Figure 6-71. Achievement of damage to underwater tunnel by placement of nuclear explosive inside tunnel.

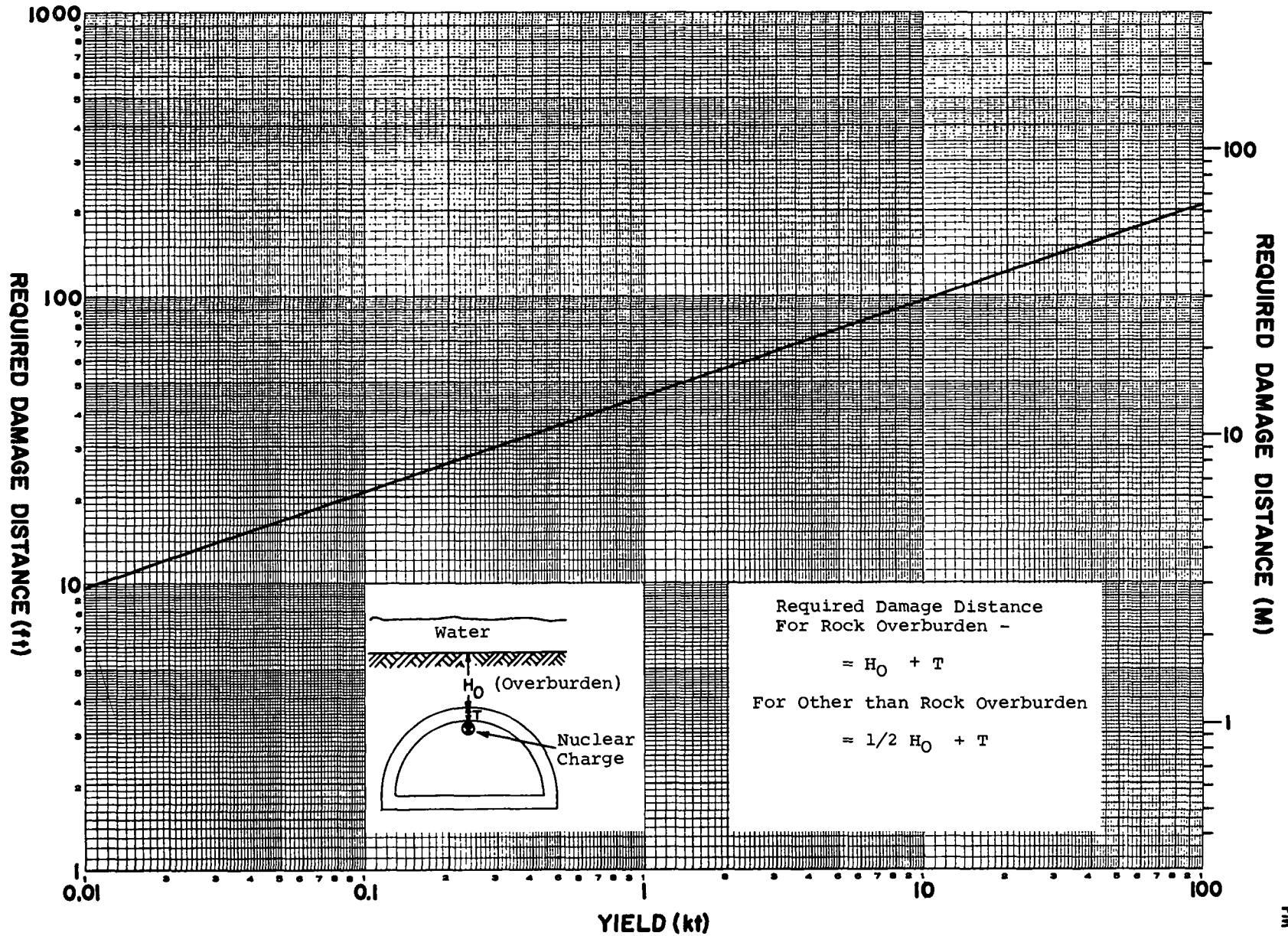


Figure 6-72. Required damage distance versus yield for burst in tunnel.

6-49. Placement On River or Harbor Bottom

This emplacement mode achieves flooding of the tunnel by cratering action in the overburden. As the amount of overburden increases, rupture of the tunnel casing may be accomplished by spalling. The radius of zone 1 damage, as with underground tunnels, becomes the yardstick for yield determination. Zone 1 damage radius is equal to the burst to tunnel distance. For underwater tunnels this

burst to tunnel distance is equal to the height of overburden (H_o) plus thickness of the tunnel casing (T). Computation of the burst to tunnel distance also takes into account the depth of burial or depth of water in this case. These computations are accomplished in figures 6-73 and 6-74 which give burst to tunnel distances for varying depths of crater as a function of yield for rock and other than rock overburden respectively.

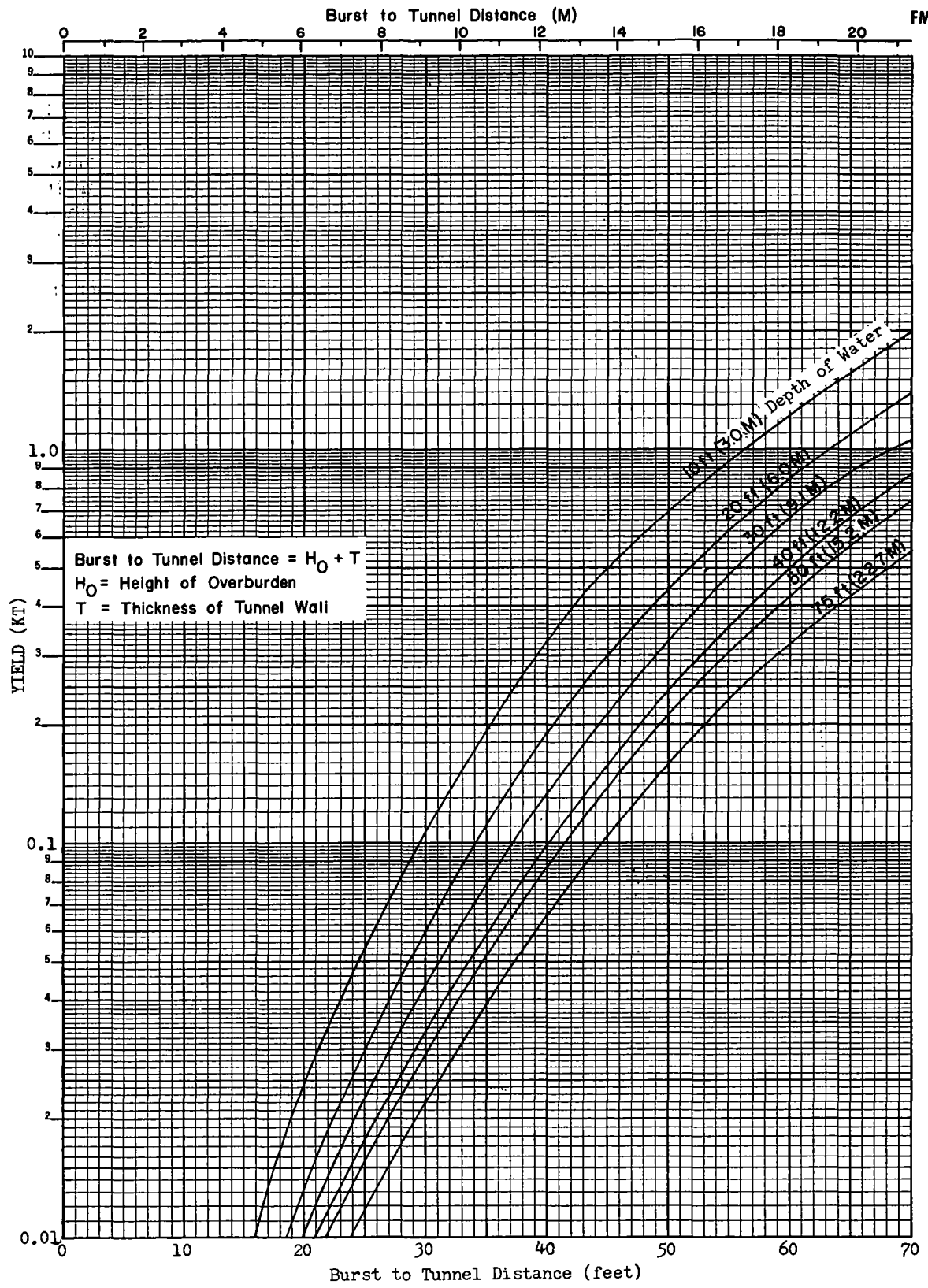


Figure 6-73. Yield versus burst to tunnel distance for varying depths of water (rock overburden).

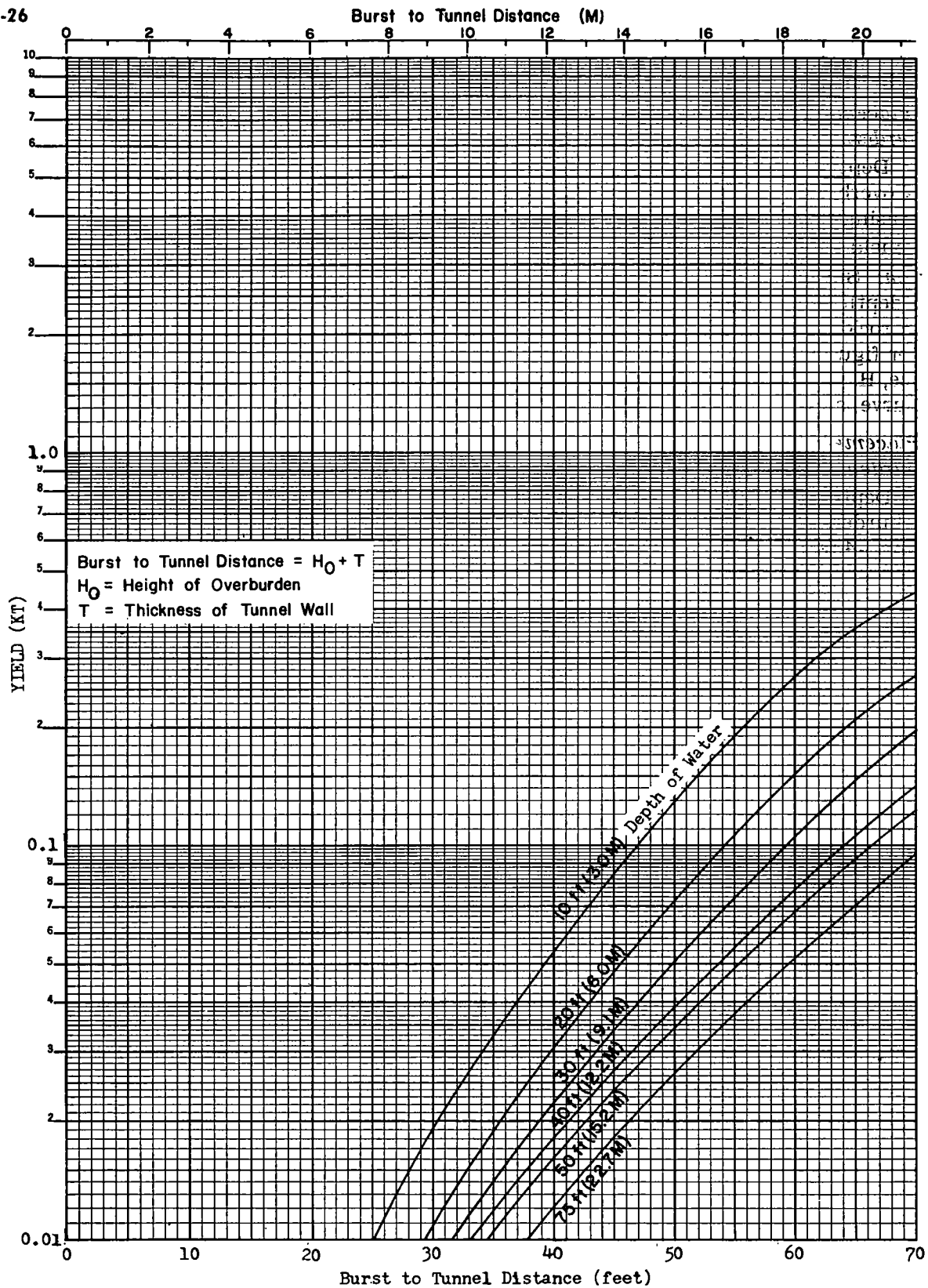


Figure 6-74. Yield versus burst to tunnel distance for varying depths of water (other than rock overburden).

6-50. Illustrative Examples**a. Placement Inside Tunnel With Rock Overburden.**

Given: Depth of water — 20 feet. Depth of rock overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Yield required to flood tunnel.

Solution: Since placement is inside tunnel, the depth of rupture concept is applicable with rock overburden.

Enter figure 6-72 with required damage distance, $H_0 + T = 15 + 4 = 19$ feet, read over to curve, and down to yield of 0.08 kt.

b. Placement on Bottom of River With Rock Overburden.

Given: Depth of water—20 feet. Depth of rock overburden — 15 feet. Thickness of tunnel casing—4 feet.

Find: Required yield.

Solution: Burst to tunnel distance = $H_0 + T = 19$ feet. Enter figure 6-73 (rock overburden) with burst to tunnel distance of 19

feet, read up to 20-foot depth of water, and over to yield of 0.011 kt.

c. Placement Inside Tunnel With Other Than Rock Overburden.

Given: Depth of water — 20 feet. Depth of overburden — 15 feet. Thickness of tunnel casing — 4 feet.

Find: Required yield.

Solution: $\frac{1}{2} H_0 + T = 7.5 + 4 = 11.5$ feet. Enter figure 6-72 with 11.5 feet, read over to curve, and down to yield of 0.02 kt.

d. Placement on River Bottom With Other Than Rock Overburden.

Given: Depth of water — 20 feet. Depth of overburden—15 feet. Thickness of tunnel casing—4 feet.

Find: Required yield.

Solution: Burst to tunnel distance = 19 feet. Enter figure 6-74 with burst to tunnel distance of 19 feet. An answer cannot be read therefore yield of 0.01 kt may be used.

Section VII. AIRFIELDS**6-51. General**

a. The most effective way to destroy the operational capabilities of an airfield is to demolish the runway complex. The runway complex is the single, indispensable element of any field. Supporting facilities such as hangers, shops, warehouses, and communication equipment are relatively easy to replace or are not absolutely essential for emergency operations.

b. Since runway characteristics vary for different airfields, the ADM emplacement locations required for destruction of a specific runway complex depend on the size, layout, and importance of the particular airfield. The following paragraphs discuss the general method of approach for using atomic demolition munitions as cratering charges to destroy the operational capabilities of runways.

6-52. Emplacement Criteria

a. The destruction of an airfield runway complex generally requires multiple-charge

detonations. One of the most important factors which must be considered in developing emplacement criteria is the minimum separation distance required between atomic demolition munitions to prevent the first detonation from damaging an adjacent munition. The separation distance for the hypothetical family of ADM is 1000 meters (3300 feet) for surface bursts. Occasionally, the requirement of separation distances can be overcome by detonating one device and returning at a later time to emplace and detonate the other. However, the level of radioactivity released to the atmosphere by the detonation of the first ADM places a significant limitation on reentry capabilities for emplacing and detonating subsequent ADM.

b. Also important in determining emplacement locations is the degree of destruction desired with regard to supporting facilities and the runway complex. The detonation of any ADM on the runway denies immediate use of the airfield to nearly all types of aircraft be-

cause of local radioactivity levels and debris created by the explosion. For long-term denial, however, the runway complex must be analyzed to determine the most effective placement of ADM to insure that the maximum continuous length of undamaged runway remaining after device detonation is less than the length required for takeoff and landing of a given aircraft.

6-53. Yield Selection

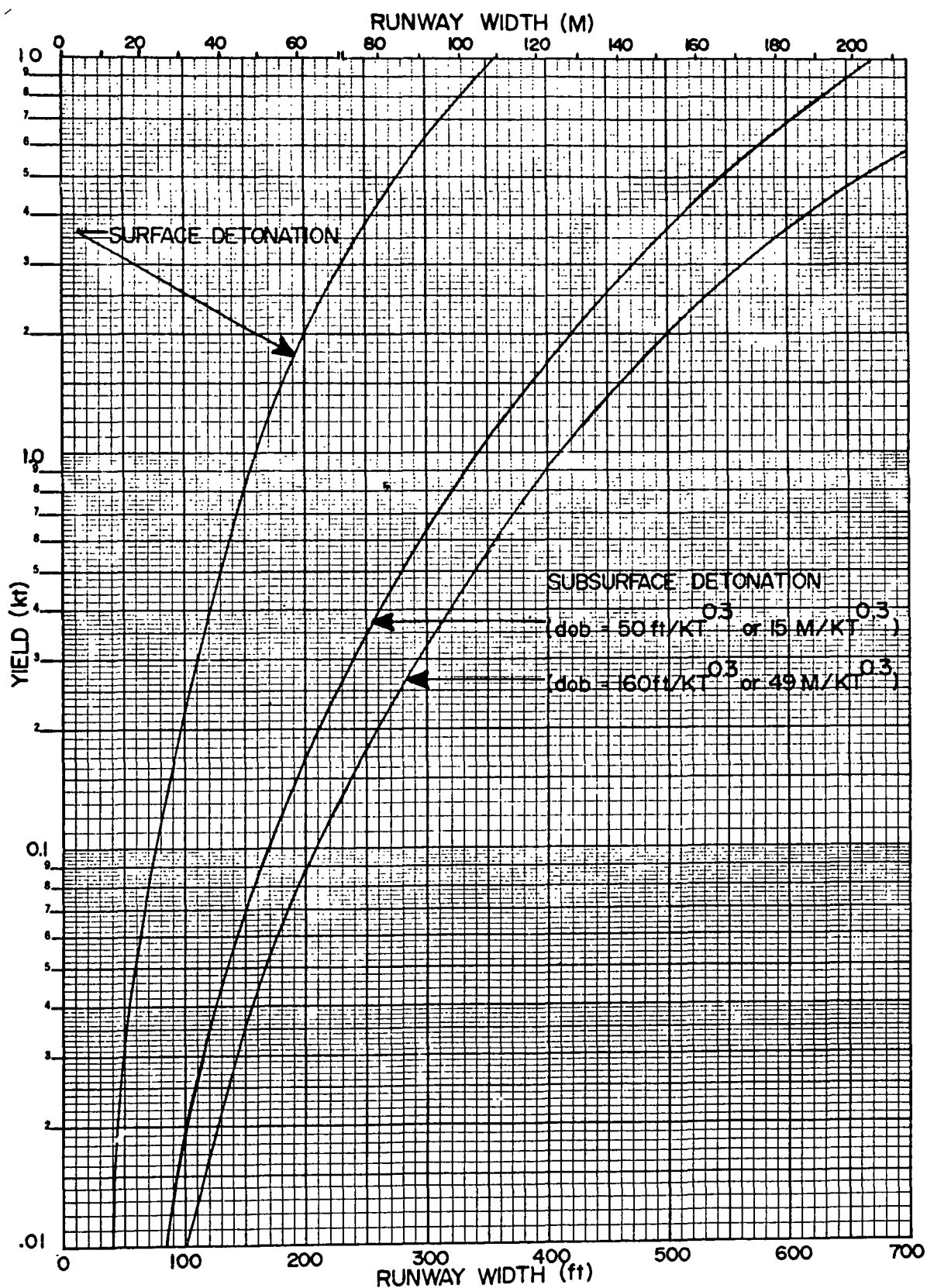
a. General. The yield required to crater a runway depends on the depth of burst of the ADM, the width and thickness of the runway, and the characteristics of the subgrade material on which the runway is constructed. The yield and depth of burst is selected so that the diameter of the rupture zone along the surface is at least equal to the runway width.

b. Surface Emplacement.

- (1) If the operational situation precludes burial of the ADM beneath the runway or in drainage culverts or utility

ducts under the runway, it is necessary to detonate the munitions on the surface of the runway.

- (2) The selection of the yield required to crater a runway is complicated by the fact that several types of material—the concrete runway and the subgrade material—must be cratered.
- (3) For surface detonations the scouring mechanism contributes significantly to crater formation. Since concrete is more resistant to scour than soil, the size of the crater plus rupture zone resulting from a surface burst on a concrete slab overlaying soil is expected to be greatly influenced. Concrete is used, therefore, as the governing medium for determining crater dimensions for surface and near surface bursts on runways. Figure 6-75 gives a curve for determining surface burst yield requirements for varying widths of runway. The curve is based upon cratering in hard rock.



★ Figure 6-75. Yield selection criteria for runway demolition.

c. *Subsurface Emplacement.* For subsurface detonations other than near surface bursts, the concrete runway slab has little effect on the dimensions of the crater produced. Even for shallow depths of burst the concrete slab is thin compared to the depth of burial, and the higher strength and density of the concrete does not greatly influence the size of the crater. The governing medium for subsurface detonations, therefore, is the subgrade material which is assumed to have cratering characteristics similar to desert alluvium. Figure 6-75 gives curves, based on cratering experience in dry soil, for determining runway cratering yield requirements for a scaled depth of 50 ft/kt^{0.3} (15 m/kt^{0.3}) and 160 ft/kt^{0.3} (49 m/kt^{0.3}). Should these depths exceed emplacement capability the procedures outlined in paragraph 6-8 are followed based on the maximum depth attainable.

★ d. *Illustrative Example.* The following ex-

ample illustrates the recommended procedure for determining the yield requirements and emplacement locations for demolition of runways.

Given: Figure 6-76 shows the layout of an airfield designed to handle heavy jet bombers. A demolition mission is planned with the objective of denying the use of the runway facilities for jet bombers and fighters. The maximum continuous length of undamaged runway which can remain after the demolition mission and accomplish the objective is 4,900 feet (1,500 meters).

Find: The ADM yields and emplacement positions required for the demolition mission for surface detonations; detonations at a scaled depth of 50 ft/kt^{0.3}; and detonations at a scaled depth of 160 ft/kt^{0.3}. Assume a minimum separation distance for multiple ADM surface detonations of 3,300 feet (1,000 meters).

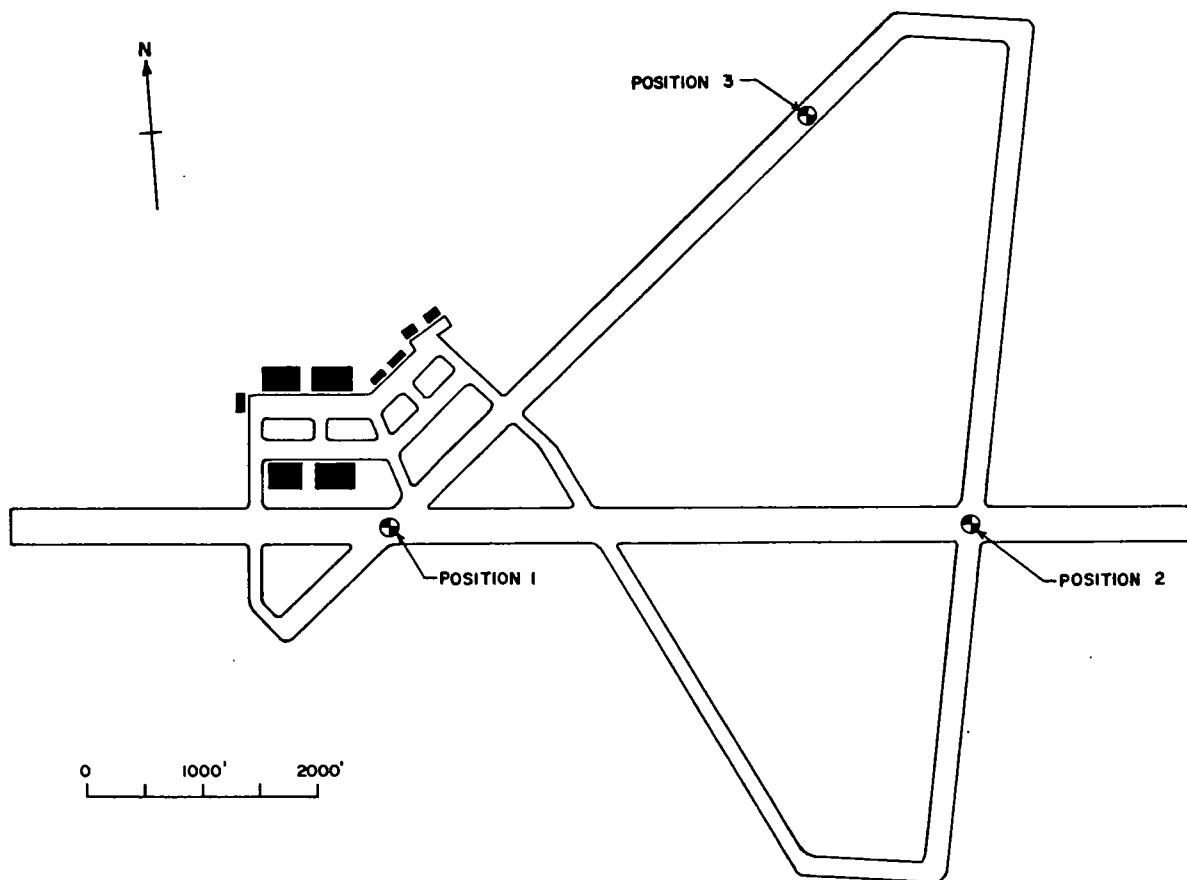


Figure 6-76. Airfield layout and ADM emplacement positions for illustrative example.

Solution:

- (1) *Emplacement positions.* The location of the ADM on the runway complex is the same for surface and subsurface detonation. Analysis of the runway layout indicates that a minimum of three ADM (identified as position 1, 2, and 3 in fig. 6-76) is required in order to deny all runways. Detonation of ADM at positions 1 and 2 reduces the undamaged length of the main east-west runway and north-south runway within the presented limits. A detonation at position 3, together with the detonation at position 1, reduces the undamaged length of the SW-NE runway to less than 4,900 feet.

(2) *Yield selections—surface detonations.*

- (a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for surface burst and runway width of 300 feet, yield required is 6.3 kt.

Answer: Use ECHO/10 kt (table 3-1).

- (b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for surface burst and runway width of 200 feet, yield required is 2.0 kt.

Answer: Use DELTA/5KT (table 3-1).

(3) *Yield selection—subsurface detonations (scaled depth of 50 ft/kt^{0.3}).*

- (a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for scaled depth of 50 ft/kt^{0.3} and runway width of 300 feet, yield required is 0.64 kt.

Answer: Use BRAVO/1 kt (table 3-1).

- (b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure

6-75 for scaled depth of 50 ft/kt^{0.3} and runway width of 200 feet, yield required is 0.17 kt.

Answer: Use WHISKEY/0.30 kt (table 3-1).

(4) *Yield selection—subsurface detonations (scaled depth of 160 ft/kt^{0.3}).*

- (a) Positions 1 and 2: Width of E-W runways = 300 feet (governing width). Referring to figure 6-75 for scaled depth of 160 ft/kt^{0.3} and runway width of 300 feet, yield required is 0.33 kt.

Answer: Use ALFA/0.5 kt (table 3-1).

- (b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for scaled depth of 160 ft/kt^{0.3} and runway width of 200 feet, yield required is 0.09 kt.

Answer: Use VICTOR/0.1 kt (table 3-1).

(5) *Summary of yield requirements.*

Yield Required

Position No.	Surface	Subsurface (50 ft/kt ^{0.3})	Subsurface (160 ft/kt ^{0.3})
1	10 kt	1 kt	0.5 kt
2	10 kt	1 kt	0.5 kt
3	5 kt	0.3 kt	0.1 kt

The yield requirements listed above are indicative of the advantage to be gained by subsurface emplacement as compared to surface bursts. Furthermore, the radioactivity released from the subsurface detonation is less than from the surface bursts because the total yield requirements for subsurface detonations are significantly smaller than for surface bursts; and the fraction of radioactivity released to the atmosphere is less for the subsurface detonation than for the surface detonation of any given yield.

Section VIII. MISCELLANEOUS ADM TARGETS**6-54. General**

Special target analysis techniques for ADM in which cratering for point targets is the governing effect were discussed in paragraphs 6-3 through 6-53. It should not be forgotten however, that ADM have a mass destruction capability and are suitable for employment on targets susceptible to nuclear effects other than cratering. Moreover, target analysis is not complete until the target area is analyzed for contingent effects. Either the visual or numerical method of target analysis is applicable for analyzing area targets utilizing the damage tables and contingent effects tables in appendix II or FM 101-31-2. This section discusses in general terms other targets appropriate for

ADM attack in which the crater effect may not be governing.

6-55. Railroad Marshaling Yards

A railway marshaling yard is an area target susceptible to blast and cratering effects. Repair facilities, roundhouses, engine sheds, and rolling stock are primarily damaged by blast while turntables and switching facilities are most effectively damaged by cratering. In cratering a railroad yard, the depth of crater is less important than width since any significant disruption of the rails requires major rehabilitation. Blast damage criteria for various yields are shown in the damage tables; cratering data may be obtained from paragraphs 6-3 through 6-14.

6-56. Ports

a. There are two general methods by which port facilities may be denied. The first is to use one or more large yield ADM to demolish the entire port as an area target. The second method is to employ a number of small yield ADM to destroy key port installations. The method of employment is, of course, dependent on the layout and size of the ports and the number and type of ADM available.

b. If one or more large yield ADM are used to attack the entire port as a single target, many of the facilities most essential to the port's operation, such as wharves and tidal locks, will remain largely undamaged. Above ground structures and equipment susceptible to blast and thermal effects will be damaged in accordance with the yield and distance from ground zero. Fires, mostly of secondary origin, will contribute to destruction. Since this method of attack destroys only those facilities near ground zero, it will hinder but not completely deny the use of a large port. The principal advantages of this method are the economy of ADM employed and the short time and little effort required for preparation.

c. If the second method is employed, a number of relatively small yield ADM consistent with separation distances may be selectively emplaced to demolish key harbor installations. Some of these facilities, such as the road and rail net serving the port, have already been discussed. Only those facilities peculiar to port operations are discussed below.

- (1) The wharves are essential to port operations. Destruction of all the wharfage, therefore, completely denies the use of the port for an extended period. However, total destruction requires the use of numerous ADM and extensive emplacement effort. There are two general types of wharf construction: deck docks supported by piles, which are susceptible to blast and thermal effects; and quay walls made from concrete or masonry, which are best

attacked utilizing the cratering effect prescribed for concrete dams or bridges (paragraph 6-15 through 6-30).

- (2) Tidal locks are necessary in some ports to maintain an adequate depth of water in the harbor area. Such facilities are attacked in a fashion similar to that prescribed for canal locks (paragraph 6-31 through 6-33).
- (3) Breakwaters are frequently necessary to protect wharf areas from wave action. Creating a large enough gap in a breakwater will handicap operations at the wharves but will rarely deny use of any of them. If it is desired to breach breakwaters, however, techniques similar to those prescribed for breaching gravity dams are applicable (paragraph 6-23 through 6-30).
- (4) The destruction of ship repair facilities is not considered here but rather under industrial plants. Methods of destroying drydocks, however, are comparable to the techniques prescribed for canal locks (paragraph 6-31 through 6-33).

d. Only by destruction of the wharves can a port be denied for an extended period of time. However, demolition of wharves generally requires a large number of ADM which may result in overdestruction in the port area and a radiation hazard to the surrounding population.

6-57. Industrial Plants and Power Facilities

a. The use of ADM permits rapid and long term denial of industrial and power installations; however, such plants are usually located in or near heavily populated areas. As a consequence, it may be necessary to limit overdestruction and confine radiation. Each industrial facility must be analyzed separately to determine the best method of denial. Two general approaches are available in attacking a large installation. One relatively large yield ADM may be selected to destroy

the entire facility or smaller ADM may be selected, consistent with separation distance, to destroy critical portions of the installation. In either event, the primary nuclear effect is generally blast overpressure.

b. The area target technique involves the selection of a yield which insures moderate to severe damage for the entire installation area. Residual radiation in the surrounding area may be reduced by placing the ADM on a tall structure with little mass such as a smokestack.

c. With selective destruction techniques, the most important elements or areas of the plant are chosen for destruction. If the installation has its own powerplant and if substitute power is not readily available, destruction of the powerplant denies use of the entire facility. Other elements crucial to operations of specified target complexes would be the blast furnaces in a steel mill or the cracking plant in a petroleum refinery. However, before employing ADM, consideration should be given to the use of conventional demolitions against targets of this type.

CHAPTER 7

TROOP AND INSTALLATION SAFETY

Section I. INTRODUCTION

7-1. General

The surface or subsurface detonation of an ADM not only produces a crater but is usually accompanied by the release of radioactivity, airblast, ground shock, missiles, dust, and thermal radiation. Employment of ADM includes an evaluation of these nuclear effects which may result in hazards to friendly troops and the civil population; contamination of water sources; or damage to installations of military, political, or humanitarian importance.

7-2. Contingency Effects Tables

The contingency nuclear effects tables in

Appendix II and FM 101-31-2 provide general guidance for estimating the range to which certain effects extend. For tactical surface bursts, these tables are usually sufficient. However, when in close proximity of friendly troops or populated areas, it is necessary for the ADM target analyst to determine the influence of a variety of nuclear phenomena. Moreover, some nuclear effects such as fall-out and blast overpressures can be suppressed, if not eliminated, by appropriate subsurface detonation. Consequently, this chapter in conjunction with chapter 2 discusses in more detail the extent of specific effects.

Section II. RADIOACTIVITY

7-3. General

The radioactivity released by a surface or shallow subsurface nuclear detonation is significant; thus troop safety from nuclear radiation is an important consideration. Adequate protective shielding is difficult to acquire. Moreover, it is reasonable to assume that personnel in the combat zone may receive repeated radiation doses. The amount and frequency of doses received in past operations and the urgency of the tactical situation must be considered in determining the degree of friendly troop exposure.

7-4. External Radiation Hazard

The external radiation hazard from a surface or underground nuclear detonation consists of initial and residual radiation. The biological response of the human body, however, is essentially the same for both (FM 101-31-1).

a. Initial nuclear radiation often produces casualties among personnel protected from

blast and thermal effects and is of considerable significance in assessing the radiation hazard.

b. Exposure to gamma radiation from fall-out is perhaps the most far-reaching type of residual radiation hazard.

c. The total dose of radiation absorbed by an individual includes both the initial and residual radiation doses received. Although partial recovery of the human body from nuclear radiation damage does occur with the passage of time, the biological effects from repeated doses received during a relatively short period of a few weeks are essentially cumulative.

d. In view of the regularity of exposure, the nonrecoverability in the first 30 days, and the slow overall recovery, the commander must also consider the consequences of using personnel previously exposed to significant but nonsymptomatic doses. To assist the commander, friendly units are divided into three

categories based on previous exposure history. FM 3-12 discusses techniques for classifying units. The categories are —

- (1) *Full Remaining Radiation Service (FRRS)*. Units in this category do not have a significant radiation exposure history.
- (2) *Limited Remaining Radiation Service (LRRS)*. Units in this category have previously received onetime or accumulated doses that are significant but not dangerous.
- (3) *No Remaining Radiation Service (NRRS)*. Units in this category have received sufficient onetime or accumulated doses to make all except insignificant future radiation exposure dangerous.

e. Military personnel operating in a nuclear environment may expect radiation exposure as a normal combat hazard. Provided that no appreciable dose has previously been received (i.e., 75 rad or less), the following degrees of risk may be used as a guide:

- (1) 5 rad or less in 24 hours is a low dose (negligible risk) and is acceptable during routine operations. However, more than 5 rad per day or 75 rad in a 30-day period is not acceptable.
- (2) 5-20 rad in 24 hours is a moderate

dose (moderate risk) and is acceptable in close support operations.

- (3) 20-100 rad in 24 hours is a serious dose (emergency risk).

Note. FM-101-31-1-2-3 will reflect a 50 rad criteria for emergency risk.

- (4) 500 rad total in any increments will probably result in the noneffectiveness of personnel and the unit.

Note. Annex D to STANAG 2083 states that no remaining radiation service (NRRS) occurs after a cumulative exposure of 150 rad is received. Reclassification of units from a more serious Remaining Radiation Service (RRS) category to a less serious one is done by the commander upon advice of the surgeon after ample observation of actual state of health of the exposed armed forces personnel has been made.

f. Delay in the onset of the effects from comparatively small doses of nuclear radiation may permit some personnel to remain effective long enough to influence a specific operation. Nevertheless, the delayed effects may considerably reduce future combat effectiveness.

g. For operations in radiologically contaminated areas, consider unit's current RRS status and use the numerical criteria given for the appropriate degree of risk in table 7-1.

Table 7-1. Nuclear Radiation Troop Safety Criteria.

Status	Total past cumulative dose	Criteria	Use this column (FM-101-31-2-3 and table II-8)
FRRS unit	< 75 rad	Negligible risk ≤ 5 rad	Negligible
		Moderate risk $> 5 \leq 20$ rad	Moderate
		Emergency risk $> 20 \leq 50$ rad	Emergency
LRRS unit	> 75 rad < 150 rad	All future risk considered Moderate or Emergency	----
		Moderate risk ≤ 5 rad	Negligible
		Emergency risk $> 5 \leq 20$ rad	Moderate
NRRS unit	> 150 rad	All future risk considered Emergency	----
		Emergency ≤ 5 rad	Negligible

7-5. Shielding and Attenuation

One of the factors influencing the amount of radiation received is the shielding that exists between the detonation and the individual. All matter absorbs some nuclear radiation; even the atmosphere offers some shielding. However, because of the high penetrating power of neutrons and gamma rays, relatively large amounts of shielding are required to provide effective protection for personnel. Dense materials such as lead offer good protection against gamma rays. Neutron shielding, however, is more complex and requires materials that can scatter and capture the neutrons together with sufficient gamma-attenuating material to minimize escape. Hydrogenous materials such as concrete and damp earth are considered a fair compromise choice to afford both neutron and gamma ray shielding.

7-6. Military Significance of the Initial Radiation Exposure Hazard

a. A knowledge of the variation of initial radiation intensities with the range from a nuclear detonation is necessary in order to assess the immediate external radiation. To date initial radiation data are available for air and surface detonations only (app. II and FM 101-31-2). The shielding of the initial radiation by dust and debris produced by a subsurface explosion, as well as absorption by the surrounding media, will cause a considerable reduction in the exposure dose at any given distance. The extent of this reduction, however, cannot be quantitatively estimated at this time.

b. In the downwind direction from a nuclear detonation, both initial radiation and fallout contribute to the total dose of nuclear radiation.

7-7. Factors Influencing Fallout Distribution

The distribution and intensity of gamma radiation resulting from radioactive fallout is primarily dependent on the following factors:

- a. The kinds and quantities of radioactive materials produced by the explosion.
- b. The amount of the total radioactivity which escapes to the atmosphere.
- c. The dimensions of the main cloud.
- d. The wind speed and direction up to maximum cloud height.
- e. The dimensions of the base surge cloud. The base surge is a physical phenomenon of nuclear detonations occurring beneath the surface of either ground or water (a surface burst does not create a base surge). It is formed in essentially the same manner for either underground or underwater bursts and consists of a low level radioactive cloud surrounding ground zero. The significance of the base surge with regard to radiation varies somewhat for the two media. In both cases, the base surge cloud radius is considered in troop safety because there will, in all probability, be a very high radiation dose rate within its confines. For the underwater burst, the base surge is transient, and its contribution to residual radiation is expected to be minor. The underground burst base surge, on the other hand, may contribute significantly to residual radiation. (See TM 23-200 for further details.)

7-8. Radioactivity Escape

- a. The radioactivity generated in cratering explosions is distributed in three ways—
- (1) A large fraction of the activity produced is trapped by particles of debris and *ejecta* which fall back into the crater or on the lip and end up buried in the rubble.
 - (2) A smaller fraction of the activity produced escapes from the crater, is injected into the dust cloud in the form of particles, and is deposited as local fallout.
 - (3) A much smaller fraction of the activity produced escapes from the crater, is injected into the dust cloud in the form of gas or solids carried by minute dust particles, and may be carried for great distances and contribute to worldwide fallout.

b. The relative amount of the activity which escapes as local fallout depends on how deep the ADM is buried compared to the depth of the resulting crater. For cratering detonations at optimum depth of burst, it has been estimated that of the radioactive debris released to the atmosphere, 80 percent is distributed in the main cloud and 20 percent in the base surge. Until data are available for shallow depths of burst, this distribution of radioactive debris is also assumed for shallow burial.

Section III. BLAST

7-10. General

a. The direct effects of blast are an important troop safety consideration.

- (1) High overpressures estimated at 45 to 65 psi for nuclear explosions cause immediate deaths while lower overpressures on the order of 20 to 35 psi may cause severe internal injuries especially to the lungs or abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from overpressures as low as 5 psi. Personnel in field fortifications may become casualties at lower incident blast overpressures built up by multiple reflections within small inclosures to casualty-producing levels.

- (2) Translation, the process by which personnel and material objects are picked up and thrown, is the basis for prediction of blast casualties to personnel in the open.

b. Secondary effects of blast also produce personnel casualties.

- (1) Flying debris, stones, and sand are converted to missiles by the blast wave, thereby causing casualties to unprotected personnel. Hot, dust-laden gases may cause burns. Airborne dust may cause irritation and possible suffocation as well as limit visibility and movement within and

7-9. Fallout Prediction Procedures

Numerous fallout prediction procedures have been developed by different agencies, most of them for specific applications. The procedures presented by TC 3-15 and TM 3-210 however, are recommended for use in tactical situations to determine those areas within which exposed, unprotected personnel may receive a militarily significant total dose of nuclear radiation in the first several hours after actual arrival of fallout.

adjacent to the target area.

- (2) Buildings or fortifications may collapse on personnel.

7-11. Degree of Risk and Damage Criteria

a. *Tactical Employment.*

- (1) In tactical operations involving the use of atomic demolition munitions, the primary area of concern is the close-in region in which structures of military significance and personnel are subjected to damaging overpressure levels from airblast. The following criteria have been established for determining troop safety distances for warned, protected personnel:

<i>Degree of risk</i>	<i>Blast overpressure—psi</i>
Negligible	4.0
Moderate	7.5
Emergency	10.0

- (2) The above blast criteria, however, do not preclude all blast injuries to protected personnel. Personnel in tanks subjected to 10 psi overpressure will probably receive no significant injuries. Personnel in foxholes, however, may become indirect blast casualties as a result of foxhole collapse. Overpressures of 7.5 psi (moderate risk) cause some light damage to unrevetted foxholes and,

as a result, may produce some indirect blast casualties. Overpressures of this magnitude are not expected to produce any direct damage to the human body. An overpressure of 4 psi (negligible risk) does not cause sufficient damage to either tanks or foxholes to produce either direct or indirect casualties.

- (3) Damage criteria for structures and field fortifications of tactical significance are given in appendix III.

b. *Preclusion of Damage Operations.* When it is desired to preclude damage to nearby structures, potential airblast damage from ADM must be evaluated.

7-12 Prediction of Close-In Airblast for Cratering Detonations

a. Close-in airblast overpressures resulting from subsurface detonations are considerably less than those generated by an air or surface burst at the same ground zero. Figure 7-1 is a family of curves representing peak air overpressures on the surface as a function of depth of burst and surface range for a yield of 1 kt. The depth of burst and the range to which a given peak overpressure extends are directly proportional to the cube root of the yield:

$$\frac{r}{r} = \frac{\text{dob}}{\text{DOB}} = \frac{W_1^{1/3}}{W_2^{1/3}}$$

Where r is the radius to which a given overpressure extends for yield W_1 (1 kiloton); R

the corresponding radius to which the given overpressure extends for yield W_2 kiloton; dob is the depth of burst for yield W_1 (1 kiloton) and DOB is the corresponding depth of burst for yield W_2 kiloton, the actual depth of burst.

b. The following example illustrates the recommended procedure for predicting close-in airblast overpressure levels resulting from cratering detonations:

Given: It is planned to use a 10-kiloton device detonated at a depth of 100 feet as a part of a preplanned barrier operation to deny enemy access through a narrow defile.

Find: The distance to which 4 psi overpressure will extend.

Solution: Applying the above scaling law, the dob for 1 kiloton is determined as follows:

$$\frac{\text{dob}}{\text{DOB}} = \frac{W_1^{1/3} \text{ kt}}{W_2^{1/3} \text{ kt}} \quad \frac{\text{dob}}{100 \text{ ft}} = \frac{1}{2.15}$$

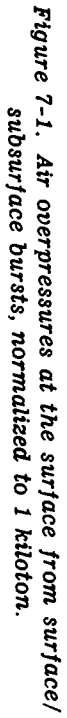
$$\text{dob} = \frac{(100)(1)}{2.15} = 46.5 \text{ ft}$$

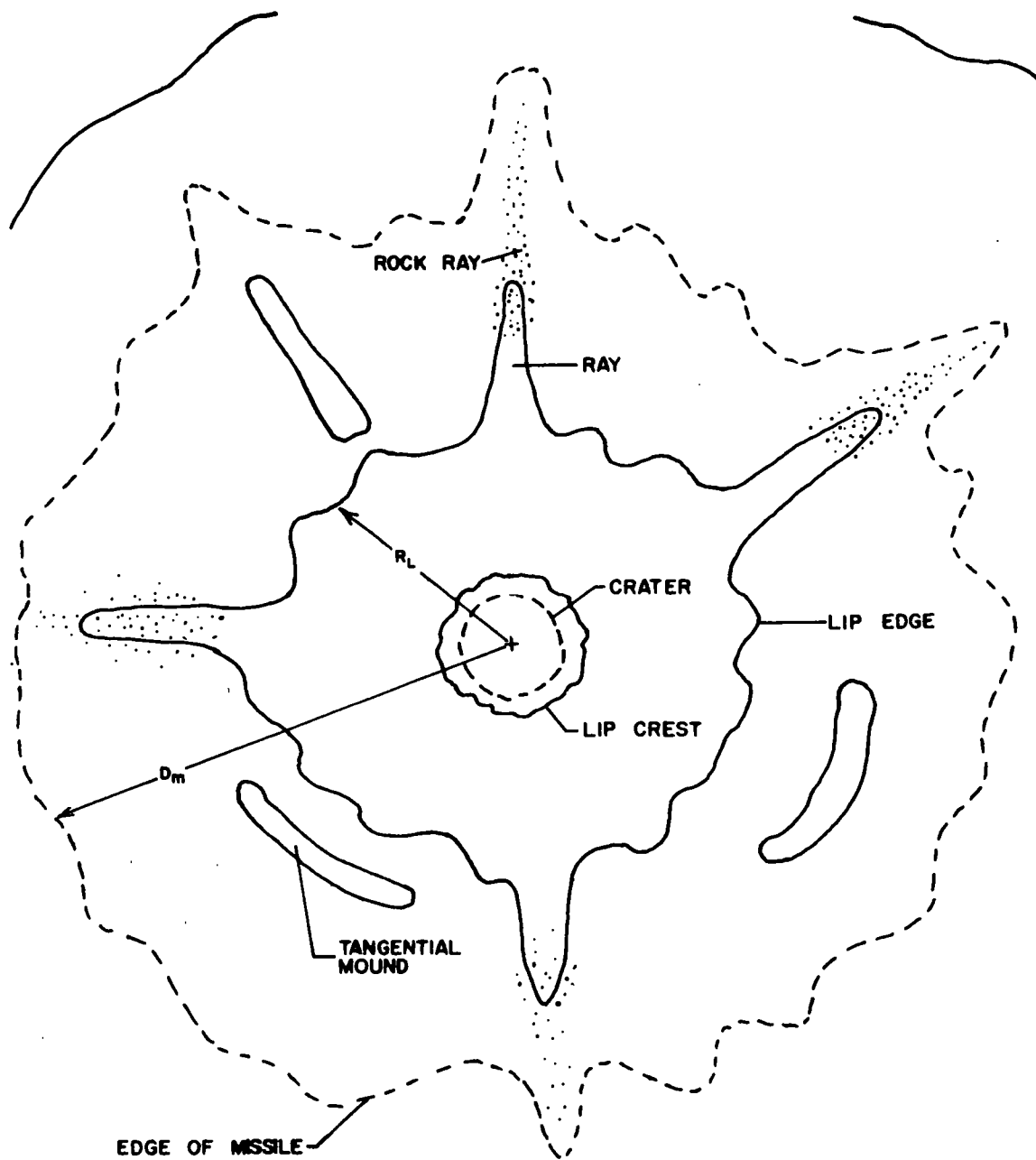
Enter figure 7-1 with $\text{dob} = 46.5 \text{ ft}$ and at the intercept of the 4 psi curve read an $r = 870 \text{ feet}$ or 265 meters . Solve for R , the radius of psi overpressure from the 10-kt device:

$$\frac{r}{R} = \frac{W_1^{1/3}}{W_2^{1/3}} \quad \frac{265\text{m}}{R} = \frac{1}{2.15}$$

$$R = 265\text{m} \times 2.15 = 570\text{m}$$

Answer: 570 meters.





NOT TO SCALE

Figure 7-3. Typical ejecta pattern.

b. Missile Sizes and Weights.

- (1) Missiles vary in weight from less than a pound to several tons. In general, at the more distant ranges, the largest and smallest sizes are not usually found. At intermediate ranges all sizes appear to be present except the largest missiles which weigh several tons and are rarely found beyond the edge of the lip (fig. 2-1).
- (2) The Armed Services Safety Board has indicated that a 1-pound missile is capable of producing a fatal injury; and upon this criterion, the minimum weight missile used in compiling the data for this section is based.

c. Missile Impact

- (1) The impact of a missile from a cratering detonation on a surface other than rock usually creates an elongated, shallow crater with a lip thrust up on the side away from the explosion. The missiles from a detonation in soil usually disintegrate upon impact.
- (2) Upon impact, rock missiles either shatter — sending a shower of fragments over the surrounding area — or rebound. Because the larger rock missiles are tumbling in flight, the

rebound pattern is usually erratic; one missile, therefore, is capable of causing multiple damage.

d. Missile Velocities. The estimated initial velocities of missiles resulting from nuclear cratering explosions in dry soil range between 400 and 1200 feet per second. The initial velocities of missiles from cratering detonations in hard noncarbonate rock range between 100 and 400 feet per second.

7-15. Maximum Missile Range

a. Figure 7-4 gives curves which can be used to estimate the maximum ranges of missiles from a cratering detonation. It should be noted that there is a wide variation in the distance to the outermost missile at various orientations around a crater. The curves in figure 7-4 represent an upper limit of missile ranges for the materials indicated.

b. It is recommended that the dry soil curve in figure 7-4 be used for nuclear detonations in all dry soils except those having a high percentage of boulders. The hard rock curve should be used for rock media, for dry soils having a high percentage of rocks or boulders, and for wet soils. For nuclear detonations in a gas-forming rock such as limestone, the maximum missile ranges determined from the hard rock curve should be increased by 20 percent to account for the anticipated increase in range resulting from greater gas acceleration.

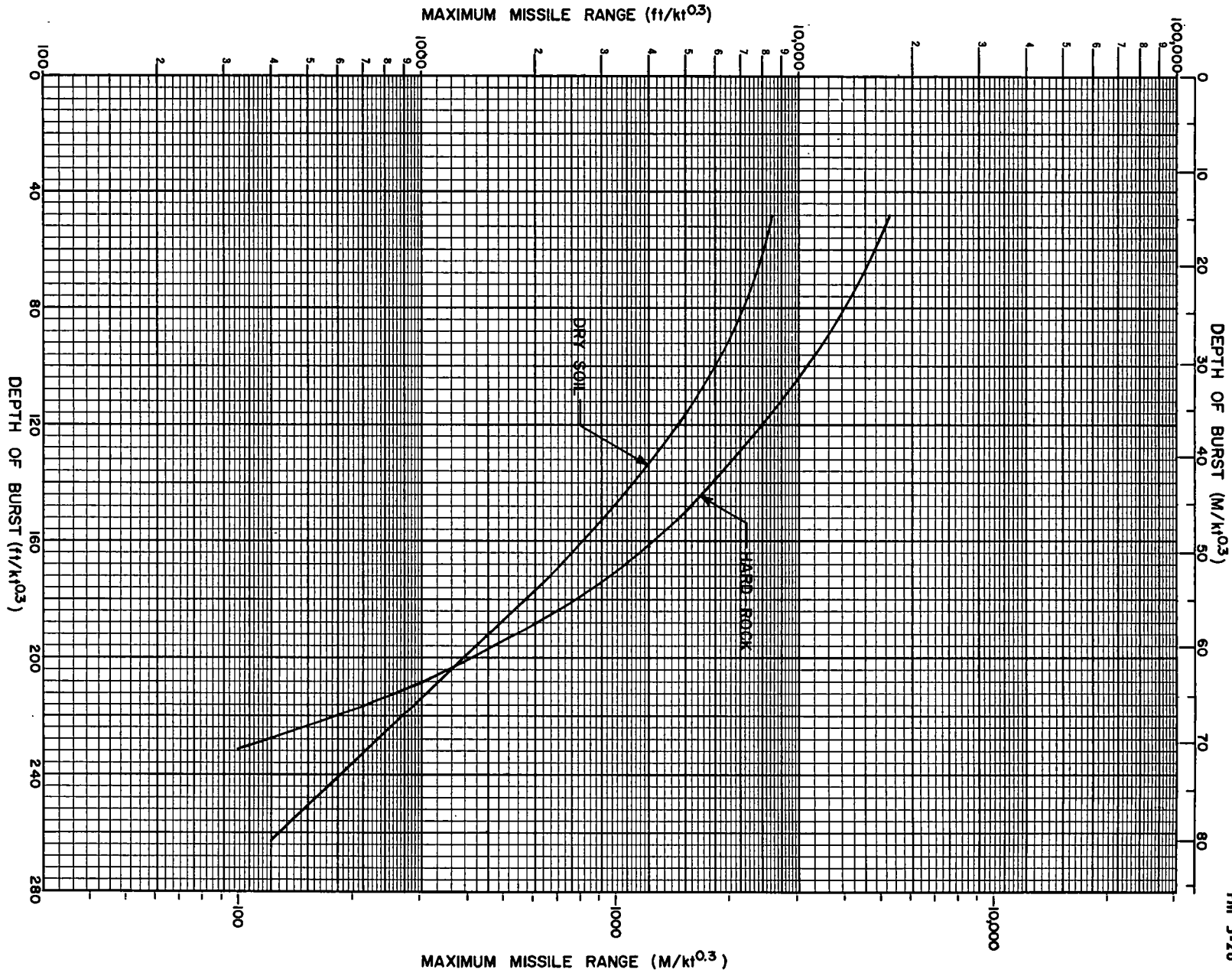


Figure 7-4. Maximum missile ranges in dry soil and hard rock.

c. The following example illustrates the recommended procedure for estimating the maximum range of missiles from cratering detonations.

Given: A 1-kiloton ADM is to be detonated at a depth of 140 feet in hard rock.

Find: The maximum missile range for the detonation.

Solution: Maximum missile range, D_m .

$$\text{dob} = \frac{\text{DOB}}{W^{0.3}} \quad \text{DOB} = 140 \text{ feet}$$

$$\text{Substituting, } \text{dob} = \frac{140 \text{ ft}}{1.000 \text{ kt}^{0.3}} = 140 \text{ ft/kt}^{0.3}$$

Using the hard rock curve in figure 7-4,

$$d_m = 5,800 \text{ kt}^{0.3}$$

$$\text{for } \text{dob} = 140 \text{ ft/kt}^{0.3}.$$

$$D_m = \text{maximum missile range} = d_m W^{0.3}$$

$$\text{Substituting, } D_m = 5,800 \text{ ft/kt}^{0.3}.$$

Answer:

$$D_m = 5,800 \text{ feet or } 1,760 \text{ meters.}$$

Section V. THERMAL RADIATION

7-16. General

In subsurface bursts, if the fireball does not penetrate through the ground surface, practically all the thermal radiation released by the detonation is used in the vaporization and melting of the medium surrounding the device. Even for shallow depths of burst in which the fireball penetrates the ground surface, the intensity of thermal radiation received at a given distance from the detonation is considerably less than for the surface burst (para. 2-10).

7-17. Intensities From Subsurface Bursts

The variation of thermal radiation intensities with distance from the detonation has been documented for airbursts and surface bursts. No data are available, however, which can be used to quantitatively estimate

the thermal radiation intensities at varying distances from subsurface bursts. Below scaled depths of approximately 15 feet/kt^{0.3} (5 meters/kt^{0.3}), the radius of the base surge cloud from a detonation is greater than the distances to which militarily significant levels of thermal radiation from a surface burst of the same yield is transmitted. For the purpose of assessing the thermal radiation hazard from subsurface bursts, therefore, it is assumed that—

a. For scaled depths of bursts less than 15 feet/kt^{0.3}, the thermal effects predicted for a surface burst may be used to estimate the intensities to be expected from a subsurface burst.

b. For scaled depths of bursts of 15 feet/kt^{0.3} or deeper, there is no militarily significant thermal radiation at distances beyond the area engulfed by the base surge cloud.

**55-1100-226-
12-Series**

Air Transportability Procedures: Atomic Demolition Charge XM127, XM127E1, XM160 and XM160E1 and Remote Command Equipment in Army Aircraft.

AI-4. Other DA Publications

TC 3-15	Prediction of Fallout from Atomic Demolition Munition
DA Pam 39-3	The Effects of Nuclear Weapons
ASubjSed 5-18	Atomic Demolition Munitions
DA Form 2706	Assignment Certificates
TB 9-1100-807- 15	Loading, Tiedown and Unloading of Nuclear Weapon Shipping and Storage Containers on Tactical Vehicles
TB IG-5	Inspector General Technical Proficiency Inspection



APPENDIX II

HYPOTHETICAL ADM EFFECTS TABLES

A2-1. General

a. This appendix provides an unclassified reference for instruction in the employment of atomic demolition munitions. The data contained herein are based on unclassified sources; consequently, the limitations of this manual must be recognized. This appendix

may be used in basic instruction in units and in service schools where utilization of classified reference material is not desirable.

b. Design characteristics of the hypothetical family of ADM listed in table 3-1 are repeated below to facilitate their use in conjunction with other tables in this appendix.

Model-yield (kt)	Cannister length		Emplacement hole diameter		Transportation weight (pounds)
	Feet	Meters	Inches	Meters	
SIERRA -----0.01	3	0.91	15	0.38	100
TANGO -----0.03	3	0.91	15	0.38	100
UNIFORM -----0.05	3	0.91	15	0.38	100
VICTOR -----0.10	3	0.91	15	0.38	100
WHISKEY -----0.30	3	0.91	15	0.38	100
ALFA -----0.50	5	1.52	30	0.76	500
BRAVO -----1	5	1.52	30	0.76	500
DELTA -----5	5	1.52	30	0.76	500
ECHO -----10	10	3.05	36	0.91	1500
GOLF -----50	10	3.05	36	0.91	1500
HOTEL -----100	10	3.05	36	0.91	1500

c. The following tables are included in this appendix:

- (1) Severe moderate blast damage for surface bursts.
- (2) Subsurface airblast damage reduction distances.
- (3) Crater dimensions for dry soil or soft rock.
- (4) Fire areas for surface burst.

- (5) Thermal criteria for fuel ignition.
- (6) Tree blowdown for surface burst.
- (7) Extent of blast overpressures for surface and subsurface bursts.
- (8) Troop safety distances for surface burst.
- (9) Light aircraft in flight safety radii for surface burst.

**Table II-1. Severe/Moderate Airblast Damage Radii for Surface Bursts
(meters)**

Material classification		Sierra 0.01	Tango 0.03	Uniform 0.05	Victor 0.10	Whiskey 0.30	Alfa 0.50	Bravo 1	Delta 5	Echo 10	Golf 50	Hotel 100
Wheeled Military Vehicles Railroad Cars Engr Truck Mounted Equip	Mod	50	60	75	90	110	125	175	325	450	825	1100
	Sev	40	50	65	80	90	100	125	200	250	400	525
Tanks and Artillery Railroad Locomotives Engr Earthmoving Equip	Mod	45	55	65	80	90	100	125	225	300	550	750
	Sev	30	45	55	65	70	75	100	175	250	450	600
Communications Equip	Sev	70	80	90	110	125	150	200	375	500	950	1250
Supply Dumps	Sev	45	50	55	65	70	75	100	175	250	450	600
Truss & Float Bridges	Mod	80	90	110	125	150	175	200	400	500	1000	1300
	Sev	70	75	85	90	100	110	175	350	475	875	1200
Field Fortifications Earth Covered Surface Shelters	Mod	45	55	65	80	90	100	125	225	300	550	750
	Sev	30	40	55	60	70	75	100	200	250	400	525
Blast-Resistant Reinforced Concrete Bldgs. Monumental-Type Multistory Wall-Bearing Bldgs. Multistory, Reinforced Concrete Frame Bldgs.	Mod	100	110	125	150	175	200	275	450	650	1250	1525
	Sev	65	75	80	90	100	125	150	300	375	675	900
Multistory, Reinforced Bldgs (small window area). Multistory, Steel Frame Office Bldgs. Multistory, Wall-Bearing Bldgs (Apt House Type). Light Steel Frame Industrial Bldgs.	Mod	150	175	200	250	275	325	475	800	1025	1825	2250
	Sev	100	110	125	175	200	250	300	475	650	1125	1425
Oil Storage Tanks Parked Combat Aircraft	Mod	225	250	275	350	400	475	600	1000	1275	2175	2750
	Sev	100	110	125	175	200	250	300	475	650	1125	1425
Wood Frame Bldgs.	Mod	550	575	625	725	800	850	1000	1675	2125	3700	4650
	Sev	175	200	225	275	300	375	650	1050	1325	2275	2875

Table II-2. Airblast Damage Reduction Distances, Subsurface Burst (meters).

DOB (meters)	Sierra 0.01	Tango 0.03	Uniform 0.05	Victor 0.10	Whiskey 0.30	Alfa 0.50	Bravo 1	Delta 5	Echo 10	Golf 50	Hotel 100
1	2	3	4	6	7	8	10	18	33	55	85
2	5	6	8	10	11	12	15	23	42	63	98
3	10	16	19	22	23	25	30	54	78	107	145
4	17	19	22	23	25	30	40	79	110	165	215
5	27	30	35	40	44	48	60	115	160	220	330
6	35	38	42	50	53	61	80	155	210	345	425
7	*	*	*	60	65	80	100	190	305	405	515
8	-----	-----	-----	*	85	105	130	220	415	500	595
9	-----	-----	-----	-----	*	145	165	275	510	585	635
10	-----	-----	-----	-----	-----	*	205	335	605	675	700
15	-----	-----	-----	-----	-----	-----	*	410	710	785	820
25	-----	-----	-----	-----	-----	-----	-----	*	800	890	950
40	-----	-----	-----	-----	-----	-----	-----	-----	*	*	1125

Note. To determine the airblast damage radii to various material targets for subsurface detonations, the distances given in this table must be subtracted from the airblast damage radii associated with surface bursts as shown in table II-1. Should the result be a negative number consider that the damage radii is zero.

Table II-3. Crater Dimensions for Dry Soil or Soft Rock *

Yield (kt)	Approximate crater dimensions (meters)								
	Surface			15 kt0.3 meters			49 kt0.3 meters		
	DOB	Diameter	Depth	DOB	Diameter	Depth	DOB	Diameter	Depth
SIERRA/0.01-----	0	10	2	4.0	21	4	12.0	26	7
TANGO/0.03-----	0	12	3	5.5	30	6	17.0	37	8
UNIFORM/0.05-----	0	14	3	6.0	34	7	19.5	42	11
VICTOR/0.10-----	0	20	4	7.5	43	9	24.0	53	14
WHISKEY/0.30-----	0	28	6	11.5	65	13	36.0	80	21
ALFA/0.5-----	0	32	7	12.5	70	14	39.0	86	23
BRAVO/1-----	0	40	8	15.0	86	17	49.0	106	28
DELTA/5-----	0	70	14	26.5	140	27	79.0	172	45
ECHO/10-----	0	90	18	30.0	173	34	97.0	210	56
GOLF/50-----	0	152	30	48.0	280	55	172.0	342	90
HOTEL/100-----	0	192	38	60.0	344	68	214.0	420	111

* For hard rock or concrete, use a 0.8 multiplication factor.

Table II-8. Troop Safety Distances *

Yield	Minimum distance (meters) required for troop vulnerability and degree of risk shown **								
	Unwarned exposed personnel			Warned exposed personnel			Warned protected personnel		
kt	NEG Risk	MOD Risk	EMER Risk	NEG Risk	MOD Risk	EMER Risk	NEG Risk	MOD Risk	EMER Risk
SIERRA/0.01-----	1,000	900	800	1,000	900	800	900	700	625
TANGO/0.03-----	1,150	1,050	925	1,150	1,050	925	950	725	650
UNIFORM/0.05-----	1,200	1,100	975	1,200	1,100	975	975	775	700
VICTOR/0.10-----	1,300	1,200	1,050	1,300	1,200	1,050	1,075	850	800
WHISKEY/0.30-----	1,350	1,250	1,100	1,390	1,250	1,100	1,100	900	850
ALFA/0.5-----	1,500	1,300	1,150	1,500	1,300	1,150	1,200	1,000	900
BRAVO/1.0-----	1,700	1,400	1,300	1,700	1,400	1,300	1,400	1,200	1,100
DELTA/5.0-----	2,100	1,700	1,550	2,100	1,700	1,550	1,700	1,400	1,300
ECHO/10.0-----	2,600	1,900	1,600	2,200	1,400	1,750	1,800	1,500	1,400
GOLF/50.0-----	4,900	3,800	3,300	3,200	2,300	1,900	2,400	1,800	1,700
HOTEL/100.0-----	6,400	5,000	4,400	4,200	2,700	2,200	3,000	2,300	2,000

* Initial effects only, surface burst.

** Yields for which radiation is the governing troop safety criteria.

Yield (kt)	Exposed		Protected
	Unwarned	Warned	Warned
Less than 8-----	Yes	Yes	Yes
8-15-----	No	Yes	Yes
16-200-----	No	No	No

Yes—Radiation is governing criteria

No—Radiation is not governing criteria

Table II-9. Light Aircraft in Flight for Surface Burst ¹

Yield kt	Aircraft safety radii—meters ²		
	Light fixed wing	Recon and obsn hel	Transport and util hel
SIERRA/0.01-----	1400	1500	1400
TANGO/0.03-----	1600	1600	1600
UNIFORM/0.05-----	2000	2000	1900
VICTOR/0.10-----	2600	2600	2500
WHISKEY/0.30-----	3000	3000	3000
ALFA/0.5-----	4000	4000	4000
BRAVO/1-----	5000	5000	5000
DELTA/5-----	9000	9000	7000
ECHO/10-----	10000	10000	9000
GOLF/50-----	17000	16000	15000
HOTEL/100-----	22000	21000	18000

¹ These radii apply to contact surface bursts. See FM 101-31-1, appendix III, annex F.

² A buffer distance has been added to these radii of safety.

**A4-4. Orders to the Demolition Guard Commander and
Demolition Firing Party Commander (STANAG 2017)**

STANAG No. 2017
(Edition No. 2)

5 October/octobre 1964

NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD
MILITARY AGENCY FOR STANDARDIZATION
BUREAU MILITAIRE DE STANDARDISATION

**STANDARDIZATION AGREEMENT
ACCORD DE STANDARDISATION**

SUBJECT
OBJET

**ORDERS TO THE DEMOLITION GUARD COMMANDER
AND DEMOLITION FIRING PARTY COMMANDER**

**CONSIGNES AU CHEF DU DETACHEMENT DE PROTECTION D'UN OUVRAGE
A DETRUIRE ET AU CHEF DU DETACHMENT DE MISE EN OEUVRE D'UNE
DESTRUCTION**

**DETAILS OF AGREEMENT (DofA)
ORDERS TO THE DEMOLITION GUARD COMMANDER AND
DEMOLITION FIRING PARTY COMMANDER**

Enclosures: Annex 'A' (DofA) — Orders to the Demolition Guard
Commander.

Annex 'B' (DofA) — Orders to the Demolition Firing
Party Commander.

GENERAL

1. It is agreed that the following procedures will be used by the NATO Armed Forces to issue orders to the Demolition Guard Commander and to the Demolition Firing Party Commander in connection with demolition operations on land. In the case of opportunity demolitions a simplified procedure may be used.

2. Three commanders are normally concerned with the execution of a demolition:—

a. The military authority who has overall responsibility, i.e., the officer empowered to order the firing of the demolition (referred to hereafter as "The Authorized Commander").

b. The Demolition Guard Commander.

c. The Demolition Firing Party Commander in technical charge of the preparation, charging and firing of the demolition.

PROCEDURE

3. Each Authorized Commander will:—

a. Determine the requirement and allot responsibility for a Demolition Guard;

- b. Establish a clear cut channel whereby the order to fire the demolition is transmitted from himself to the Demolition Guard Commander;
 - c. Ensure that this channel is known and understood by all concerned;
 - d. Ensure a positive, secure means for transmitting the order to fire;
 - e. Specify whether the Demolition Guard Commander is authorized to order the firing of the demolition on his own initiative if the enemy is in the act of capturing it.
4. Where a demolition is to be prepared which is important to the operational plan, the Authorized Commander will normally appoint a Demolition Guard, the Commander of which will be responsible for:—
 - a. Ensuring, if so ordered, that the demolition is not captured intact by the enemy;
 - b. Giving to the Demolition Firing Party Commander the orders for changing the state of readiness of the demolition and the firing orders.
5. Instructions in respect of the Demolition Guard Commander are at Annex 'A' (DofA) and instructions in respect of the Demolition Firing Party Commander are at Annex 'B' (DofA). These forms will be used whenever time and conditions permit.
6. After all parts of the form at Annex 'A' (DofA) have been completed by the appropriate authority, the form will be issued to the Demolition Guard Commander and will be retained by him until the demolition has been completed.
7. After Parts I, II and III of the form at Annex 'B' (DofA) have been completed by the appropriate authority, the form will be issued to the Demolition Firing Party Commander and will be retained by him until the demolition has been fired.
8. The contents and paragraph numbers of the forms issued by each national authority will conform exactly to the examples at Annex 'A' (DofA) and Annex 'B' (DofA). The forms issued by each national authority should also conform as closely as possible, both in size and shape, to these examples. It is preferable that the forms should be printed on heavy durable paper which at the same time is thin enough to allow a carbon copy to be made; the colour should be yellow for the form at Annex 'A' (DofA) and white for that at Annex 'B' (DofA).
9. To facilitate the use of these standard NATO forms, it is recommended that certain general instructions to Demolition Guard Commanders and Demolition Firing Party Commanders be included in appropriate unit standing Operating Procedures/Standing Orders. The most important of these instructions have been included in Part VII of Annex 'A' (DofA) and Part V of Annex 'B' (DofA).

**A4-5. Format for Orders to the ADM Firing Party Commander
(DA Form 3065-R)**

FM 5-26

NO ADM WILL BE DETONATED WITHOUT APPROVAL OF COMPETENT AUTHORITY		
ATOMIC DEMOLITION MUNITION FIRING ORDER <i>(FM 5-26)</i>		NOTE: All items will be completed. This order must be authenticated <i>(Item 12)</i> and handed to Commander of ADM Firing Party.
This form modifies STANAG 2017 & is for ADM employment only.		
TO: _____ You will fire target identified below in accordance with the following instructions:		
1. TARGET		
a. LOCATION <i>(clear)</i>	b. LOCATION <i>(code word)</i>	
c. DESCRIPTION		
2. MUNITION DATA		
a. TYPE AND YIELD ADM	b. LOCATION OF MUNITION <i>(SASP or Unit Storage)</i>	
3. CONTROL		
a. EXECUTING COMMANDER	b. LIAISON OFFICER	c. ALTERNATE LIAISON OFFICER
4. EMPLACEMENT DATA <i>(Check one and fill in specification where necessary)</i>		
a. ☐ SURFACE EMPLACEMENT		
b. ☐ POINT OF DETONATION		
c. ☐ DEPTH OF BURST		
5. RENDEZVOUS POINT		
6. FIRING OPTIONS DESIRED		
a. PRIMARY		
b. FIRST ALTERNATE		
c. SECOND ALTERNATE		
a. FIRING SITE	b. ALTERNATE FIRING SITE	
8. DETONATION <i>(Check desired method and fill in specifications where necessary)</i>		
a. ☐ ASAP		
b. ☐ ON ORDER		
c. ☐ DETONATE AT		
9. SECURITY REQUIREMENTS		
NO ADM WILL BE DETONATED WITHOUT APPROVAL OF COMPETENT AUTHORITY		

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Figure IV-2. DA Form 3065-R.

A4-11

NO ADM WILL BE DETONATED WITHOUT APPROVAL OF COMPETENT AUTHORITY	
10. CODE WORDS (If used)	
ACTION TO BE TAKEN	CODE WORD
a. CHANGE STATE OF READINESS FROM SAFE TO ARMED	
b. CHANGE STATE OF READINESS FROM ARMED TO SAFE	
c. FIRE THE DEMOLITION	
d. YOU ARE NOW AUTHORIZED TO FIRE THE DEMOLITION IF THE ENEMY IS IN THE ACT OF CAPTURING IT	
e. YOU WILL ORDER THE FIRING OF THE DEMOLITION ONLY UPON THE ORDER OF THE RELEASING COMMANDER	
f. SPECIAL AUTHENTICATION INSTRUCTIONS, IF ANY	
11. OTHER INSTRUCTIONS	
12. CHANGES (Firing, safing, cancelled mission, etc.)	
ACTION TAKEN	SIGNATURE OF LIAISON OFFICER
ACTION TAKEN	SIGNATURE OF LIAISON OFFICER
ACTION TAKEN	SIGNATURE OF LIAISON OFFICER
ACTION TAKEN	SIGNATURE OF LIAISON OFFICER
13. AUTHENTICATION	
BY ORDER OF:	
PRINTED NAME	SIGNATURE
NO ADM WILL BE DETONATED WITHOUT APPROVAL OF COMPETENT AUTHORITY	

Figure IV-2 — Continued.

A4-6. Suggested ADM Unit SOP Format*

(Classification)

XXth Engineer Bn
 Fort Belvoir, Virginia
 (date)

ANNEX E—Atomic Demolition Munitions (ADM)**1. APPLICATION**

This SOP supersedes all previous SOP and applies except as modified by battalion orders. Subordinate unit SOP will conform. Attached units will comply with this SOP.

2. REFERENCES

(List SOP, directives and/or policies of higher headquarters in which this SOP is based).

3. ADMINISTRATION*a. Responsibilities.*

- (1) For preparation and periodic review of the SOP.
- (2) For requisitioning and posting of changes to all pertinent publications.

b. Records and Reports.

- (1) (List required reports to higher headquarters.)
- (2) (List required test and maintenance records as specified by pertinent manuals.)
- (3) Instructions on Tactical Damage Evaluation Reports.

4. PUBLICATIONS

- a. Requisitioning Procedure.*
- b. Reference Material-appendix 1.*
- c. Unsatisfactory Reports.*
 - (1) Preparation and study of proposals.
 - (2) Submission and review procedures.
 - (3) Ammunition Condition Reports (DA Form 2415) and Equipment Incident Reports.

5. SUPPLY

- a. Authority (TOE, TA, TD, EMR, etc.).*
- b. Equipment Lists (Refer to the appropriate parts list).*
- c. Requisition procedures (including local requirements).*
- d. Property accountability (including local requirements).*

6. SAFETY*a. General.*

- (1) A statement allowing no deviation from the approved checklist.
- (2) Applicable safety requirements deemed necessary. (Preventive maintenance, driver training, preoperational vehicle checks, etc.)
- b. Electrical Safety requirements.*
- c. Explosive Safety requirements.*
- d. Nuclear Safety requirements.*
- e. Disposal of contaminated material.*

7. TRAINING

ADM training should be conducted in the following areas:

- a. Prefire Procedures.*
- b. Command Site Preparation.*
- c. Formal Instruction.*
 - (1) Classroom presentation.
 - (2) Manual study.
 - (3) Review of SOP and demolition fire orders (DFO).

(Classification)

* Applicable portions are also pertinent for engineer units below battalion.

(Classification)

d. Support Training

- (1) Convoy procedure.
- (2) Emplacement site preparation.
- (3) Team organization.
- (4) Site security.

(Other than an accident or incident.)

8. SECURITY**a. Statement of Policy.**

- (1) Importance.
- (2) Possible consequence of violations.
- (3) Responsibilities.

b. Document Control.**c. Classified Item Control.****d. Classified Study Procedures.****e. Clearances — appendix 2.****f. Access List — appendix 3.****9. TRANSPORTATION**

a. Convoy Composition (list 3 or 4 different types; do not attempt to standardize beyond minimum requirements). List these as type I, type II, etc., so that the assemblyman, when instructed as to convoy type for a particular operation, may refer to the ADM SOP.

b. Air Movement Plans. (List details of ADM movement by aircraft to include security and handling requirements.)

c. Personnel and Duties. (List duties and required clearances.)

- (1) Convoy Commander (ranking officer).
- (2) Courier Officer (may also be convoy commander).
- (3) Escort guards.
- (4) Convoy guards.

c. Control.

- (1) Convoy coordination.
- (2) Coordination with tactical security forces.
- (3) Procedures in case of unavoidable delay or mechanical breakdown.

10. ORGANIZATION FOR ADM MISSIONS

Note. This paragraph outlines a suggested organization of the ADM firing party for conduct of an ADM mission. Missions in support of allied forces will require modifications.

a. Team Leaders. (Indicated by position rather than name) — Example: CO, EXO, Plt Ldr, Plt Sgt, Sqd Ldr, etc.

b. Composition and Duties.

- (1) Prefire Team (for composition see table 1).

- (a) Pickup of ADM equipment — appendix 4.
- (b) Transportation procedures.
- (c) Prefire procedures — appendix 5.
- (d) Remote command fire procedures — appendix 6.
- (e) Basic immediate security of munition.
- (f) Emergency disarm procedures — appendix 7.

- (2) Support Team (size dependent on type of mission).

- (a) Pickup and transportation procedures (mines, camouflage, tentage, etc).
- (b) Preparation of the emplacement site (construction, installation of mines; wire; booby traps; etc.).
- (c) Preparation of command site(s).

- (3) Security Team (size dependent on terrain, tactical situation, etc.).

- (a) Provide convoy guards during the transportation phase.
- (b) Establish emplacement site security prior to the arrival of the munition.
- (c) Provide security at the completed emplacement site until prearranged departure time.

(Classification)

 (Classification)

- (d) Provide security detail at the command site until after detonation.

11. ACCIDENT AND INCIDENT PLAN

This paragraph will cover such contingencies as accidents, incidents, or delays to include explosions, nuclear contamination, misfire malfunction, and damage.

a. General. It is recommended that a set of code words be prepared, if not already accomplished by higher headquarters, to allow understanding of the situation over an unclassified means of communication.

b. Accident.

- (1) Definition. (The definition of an accident may be found in the Munition Prefire Manual.)
- (2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)
- (3) Notification. (Person to be notified by name or duty, location, communication channel.)
- (4) Continuing Action. (Protective measures, security, control, procedures for requesting Ordnance or EOD teams.)
- (5) Follow Up and Reports.

c. Incident.

- (1) Definition. (The definition of an incident may be found in the Munition Prefire Manual.)
- (2) Immediate Action. (List local and higher headquarters requirements in full detail when possible.)
- (3) Notification. (Person to be notified by name or duty, location, communication channel.)
- (4) Continuing Action. (Protective measures, security, control, procedures for requesting Ordnance of EOD teams.)
- (5) Follow Up and Reports.

12. EMERGENCY DISPOSAL AND DESTRUCTION

- a. Priorities of Denial.*
- b. Authority for Emergency Disposal and Destruction.* (List chain of command having the authority to order disposal or destruction.)
- c. Methods of Disposal.*
- d. Methods of Destruction.*
- e. List of Materials Needed.*

APPENDIXES:

- Appendix 1 — List all FM, TM, TC, Ordnance Special Weapons Technical Instruction, etc., necessary for ADM Firing Party Personnel to scan, read, or Study, and the frequency of revision.
- Appendix 2 — List all cleared personnel within the battalion indicating their proper clearance.
- Appendix 3 — Include the Permanent Access List and the procedures for escorting visitors into the emplacement site.
- Appendix 4 — Include here a checklist of pickup requirements. (Signature cards, SASP access requirements, documents, forms and records, ramps, lifting devices, tie down equipment, etc.).
- Appendix 5 — Include here a prefire checklist for each munition.
- Appendix 6 — Include here a checklist for remote command site. (Location, foxholes, security, firing procedure, change of mission procedure, etc.).
- Appendix 7 — Include here a checklist for the emergency disarm of all munitions for which there is a checklist in appendix 5.

 (Classification)

ADM RECONNAISSANCE RECORD (FM 5-26)		FILE NUMBER	DATE/TIME
SECTION I - HEADING			
	NAME AND POSITION	GRADE	ORGANIZATION
RCN ORDERED BY			
RCN CONDUCTED BY			
SECTION II - ADM TARGET REPORT NUMBER _____			
A. WARNING (Code Word)	ALFA		
B. NATURE OF TARGET (include critical dimensions and desired damage)	BRAVO		
C. GROUND ZERO (UMT grid coordinates)	CHARLIE		
D. DOB OR POINT OF DETONATION	DELTA		
E. GOVERNING NUCLEAR EFFECT	ECHO		
F. TIME OF DETONATION	FOXTROT		
G. METHODS OF FIRING	GOLF		
H. LOCATION OF FRIENDLY TROOPS	HOTEL		
I. ENGINEER SUPPORT REQUIRED	INDIA		
J. SPECIAL EQUIPMENT REQUIRED	JULIET		
K. ADDITIONAL REMARKS	KILO		
NOTE: Target sketches are shown on reverse side.			

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APPENDIX VI

ADM YIELD DETERMINATION PROCEDURE FOR TARGETS DAMAGED PRINCIPALLY BY AIRBLAST

A6-1. General

ADM yield determination procedures for targets damaged principally by airblast involve both the visual and numerical methods of damage estimation. Although the procedures are similar to those developed for use with nuclear weapons, the "no delivery error" characteristic of ADM simplifies the steps involved. The ultimate objective of each method is to establish the required radius of damage. This R_D is then compared with those recorded in the damage tables (app. II), and the minimum ADM yield with an R_D equal to or greater than the R_D required is selected.

A6-2. Point Targets (Numerical Method)

a. General. Single buildings, bridges, and similar structures are termed point targets. In addition, an area target that is small in comparison to the radius of damage ($R_D \leq 5 R_T$) is considered a point target. Associated with the engagement of a point target is the probability of damaging (P) the target to a desired degree. For example, an 85 percent probability ($P = 85\%$) of severe damage to the target means the target has 85 out of 100 chances of receiving severe damage and 15 out of 100 chances of receiving less than severe damage.

b. Yield Determination Procedure.

- (1) Enter the point target graph exten-

sion, figure VI-1, with the desired probability of damage (P), expressed as a percentage.

- (2) Intersect the diagonal line and establish the value of the d/R_D ratio.
- (3) Determine the displacement distance (d).
- (4) Solve for the radius of damage required: $R_D = d/\text{value of ratio}$.
- (5) From the damage, appendix II, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Illustrative Example.

Given: The commander desires a high assurance ($P = 90\%$) of causing moderate damage to oil storage tanks located 200 meters from ground zero.

Find: The minimum ADM yield to meet the commander's guidance.

Solution:

- (1) Enter figure VI-1 with $P = 90\%$.
- (2) $d/R_D = .72$.
- (3) $d = 200$ meters.
- (4) $R_D = d/.72 = 200/.72 = 278$ meters.
- (5) Appendix II; TANGO/.03 kt/ADM, $R_D = 300$ meters.

Answer: TANGO/.03 kt/ADM.

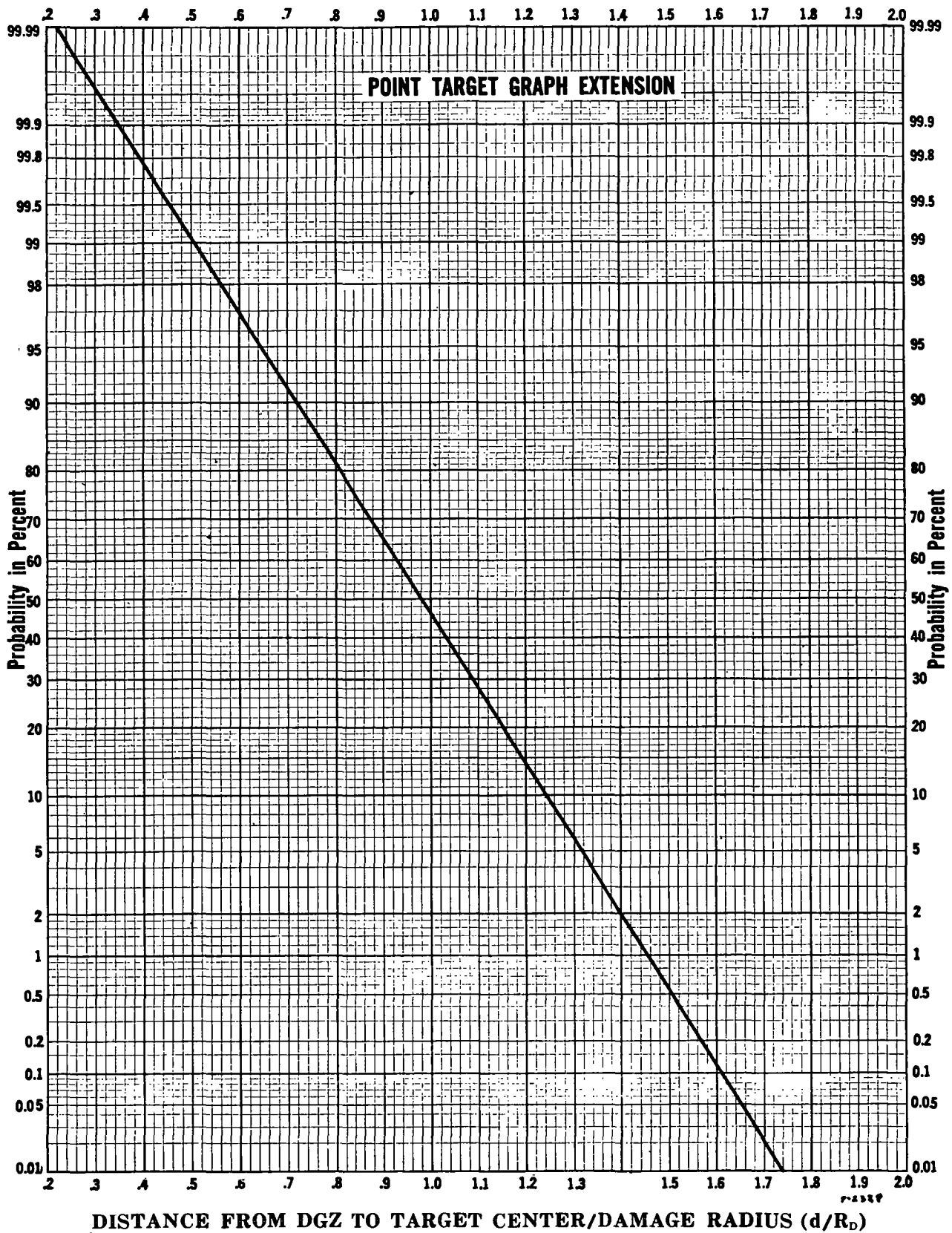


Figure VI-1. Point target graph extension.

★A6-3. Area Targets (Visual Method)

a. *General.* The visual method of analysis consists of a visualization of the fraction of the target covered by the radius of damage using ground zero as the reference point. In order to facilitate this visualization, a transparent circular map scale inscribed with a series of concentric circles and arcs at 100m or 200m intervals is used (app V, FM 101-31-1).

b. Yield Determination Procedure.

- (1) Draw a scaled representation of the target.
- (2) With a circular map scale or a comparable substitute, and using ground zero as a reference point, estimate visually the radius of damage required to achieve the fractional coverage (f) desired.
- (3) Select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Illustrative Example.

Given: An engineer equipment park measures 100 meters long and 30 meters wide. The commander desires at least moderate damage to 50 percent of the target area. The situation requires the ADM to be emplaced at the entrance to the equipment park which is situated midway along the short axis.

Find: The minimum ADM yield required to meet the commander's guidance.

Solution:

- (1) The engineer equipment park is drawn to scale.
- (2) With the circular map scale, the required R_D is found to be slightly greater than 50 meters for at least 50 percent coverage.
- (3) From table II-1 the following R_D 's for moderate damage are obtained.

	SIERRA 0.01kt	TANGO 0.03kt
Engr Truck Mounted Equip	50m	60m
Engr Earthmoving Equip	45m	55m

★A6-4. Area Targets (Numerical Method)

a. *General.* The numerical method of analysis may be used with either circular or approximately circular targets. Ground zero may be at or displaced some distance (d) from target

center. The numerical method requires the use of the ADM fractional coverage nomograph, figure VI-2, which has been devised to replace the graphics required by the visual method.

b. Yield Determination Procedure (GZ at Target Center).

- (1) Determine the radius of target (R_T).
- (2) Establish the R_D/R_T ratio required to achieve the fractional coverage (f) desired. This is read directly from the ADM fractional coverage nomograph (fig. VI-2) at the point where the fractional coverage curve of interest intercepts the R_D/R_T index.
- (3) Calculate the radius of damage required; $R_D = R_T \times (\text{value of ratio})$.
- (4) From the appropriate damage table, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. *Yield Determination Procedure (Displaced GZ).* Except for entering the fractional coverage nomograph with the d/R_T ratio, the procedure follows that outlined in b above.

d. Illustrative Example (GZ at Target Center).

Given: Moderate damage to 40 percent of the railroad cars located in a railway marshaling yard is desired. The diameter of the target is 260 meters.

Find: The minimum ADM yield required to meet the above requirements.

Solution:

- (1) $R_T = 260/2 = 130$ meters
- (2) From figure VI-2; For $f = .40$, $R_D/R_T = 0.65$
- (3) $R_D = 0.65(R_T) = 0.65(130) = 85$
- (4) From table II-1 VICTOR/0.10kt/ADM, $R_D = 90$ meters.

Answer: VICTOR/0.10 kt/ADM

e. Illustrative Example (Displaced GZ).

Given: In the above problem, limiting requirements have caused ground zero to be displaced 100 meters from target center.

Find: The minimum ADM yield required to meet the 40 percent coverage requirements as stated previously.

Solution:

(1) $R_T = 130$ meters, $d = 100$ meters.

(2) Enter figure VI-2 with $d/R_T = 100/130 = 0.77$. For $f = 0.40$, $R_D/R_T = 0.87$

(3) $R_D = 0.87 (R_T) = 0.87(130) = 113$ meters.

(4) From table II-1 ALFA/0.50kt/ADM, $R_D = 125$ meters.

Answer: ALFA/0.50kt/ADM.

$$\frac{\text{DISPLACEMENT DISTANCE}}{\text{TARGET RADIUS}} = \frac{d}{R_T}$$

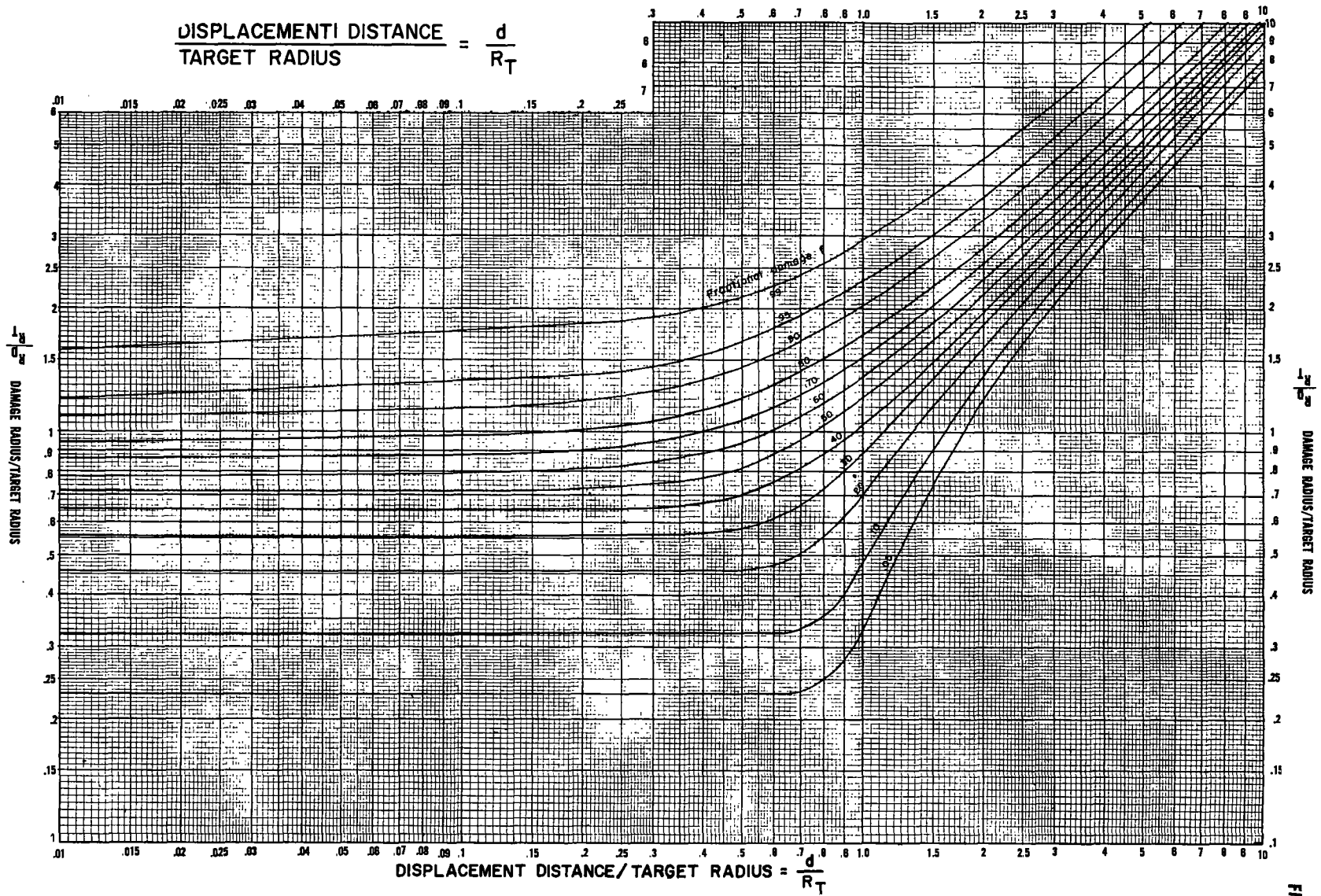


Figure VI-2. ADM area target coverage nomograph.

A6-5. Preclusion of Damage

a. General. In many instances, the probability of not causing damage (Q) will be of interest to the target analyst. This is simply the reciprocal value of the probability of damaging the target. Preclusion of damage problems involve the use of the point target extension graph (fig. VI-1) for both point and area targets. In the latter case, the point on the periphery which is nearest ground zero is taken as being representative of the area target. In most instances, the probability will be specified and the separation distance (d) required between ground zero and the target calculated.

b. Procedure.

- (1) Figure VI-1 indicates the probability of achieving a particular degree of damage therefore enter the graph with a value of $P = 100\% = Q$.
- (2) Intercept the diagonal line and establish the d/R_D ratio.
- (3) Determine the radius of damage (R_D)

from Appendix II.

- (4) Calculate the separation distance (d) required.

c. Illustrative Example.

Given: A very high assurance (99%) of not causing moderate damage to a highway truss bridge in the vicinity of an ADM target is desired. The yield involved is a SIERRA/.05 kt/ADM.

Find: The separation distance (d) required to meet the above requirement. Assume that ground zero is located side-on to the bridge.

Solution:

- (1) $P = 100\% - Q = 100\% - 99\% = 1.0\%$.
- (2) Figure VI-1; $d/R_D = 1.45$.
- (3) Appendix II; $R_D = 110$ meters.
- (4) $d = R_D (1.45) = (110) (1.45) = 160$ meters.

Answer: 160 meters.

APPENDIX VII

ILLUSTRATIVE EXAMPLES IN ADM TARGET ANALYSIS

A7-1. General

The examples used in this appendix illustrate the procedural steps outlined in paragraph 5-4 with regard to the detail analysis of ADM targets. These procedures are provided for guidance only since it is realized that the analyst will develop procedures of a more direct nature commensurate with his experience.

A7-2. Illustrative Examples*a. Example Problem No. 1.*

- (1) *Given:* A rapid withdrawal of friendly troops which may necessitate the denial of prestocked military vehicles is being contemplated. The vehicles are uniformly distributed in the pre-stock site shown in figure VII-1. The area is approximately circular with a radius (R_T) equal to 150 meters. The commander desires moderate damage to 75 percent of the target. In addition, the commander wants to preclude tree blowdown on Highway 50 as an obstacle to wheeled vehicles and to achieve a high assurance (90%) of not subjecting the village north of the target to an overpressure of 1 psi. The SOP specifies no more than a negligible risk to friendly troops. The closest friendly elements are 1500 meters south of target center, are the FFRS radiation service category, and are to be considered as warned and protected. Effective fallout winds are from the southwest. The allocation includes the following ADM:
 - (a) ALFA/0.5 kt/ADM.
 - (b) BRAVO/1.0 kt/ADM.
 - (c) DELTA/5.0 kt/ADM.
- (2) *Find:* The most suitable ADM for this denial operation to include the location of ground zero and the frac-

tional coverage to the target.

(3) Solution:*(a) Step 1. Identify pertinent information.*

1. *Target information.* An area target ($R_T = 150m$) composed of military vehicles.
2. *Friendly forces.* Troops in the vicinity are warned and protected, 1500 meters southwest of target center. Negligible risk is not to be exceeded.
3. *Command guidance.* At least 75 percent coverage based on a moderate level of damage is desired. Preclude tree blowdown on Highway 50, approximately 375 meters east of target center; provide at least a 90 percent assurance of not subjecting the village, situated 1600 meters north of target center, to 1 psi overpressure.
4. *ADM allocation.*
ALFA/0.5 kt
BRAVO/1.0 kt
DELTA/5.0 kt

- (b) *Step 2 Tentatively select point of detonation.* Initially, target center is selected as the ground zero location. A surface burst is planned in order to maximize the desired effect (airblast) and to facilitate emplacement. The resultant fallout does not affect tactical operations or the civilian population in the village in view of current wind conditions.
- (c) *Step 3. Eliminate obviously unsuitable weapons.* The nature of

this mission is such that none of the ADM allocated are eliminated at this time. Weight and size of the ADM do not pose any operational difficulty.

(d) *Step 4. Determine data for:—*

1. *Estimating damage to the target* (table II-2) The numerical method is used although the visual method of damage estimation is also applicable.

	R_D	R_D/R_T	f (fig. VI-2)
ALFA/0.5 kt	----125m	0.83	63%
BRAVO/1.0 kt	--175m	1.17	94%
DELTA/5.0 kt	--325m	2.16	100%

2. *Troop safety* (table II-8). Since troops are in the FRRS radiation service category, the warned-protected, negligible risk safety distances are as follows:

ALFA/0.5 kt -----1200m†
 BRAVO/1.0 kt -----1400m
 DELTA/5.0 kt -----1700m

3. *Bonus effects and limiting requirements* (table II-6).

- (a) *Tree blowdown distances* (type III forest).

ALFA/0.5 kt -----200m
 BRAVO/1.0 kt -----300m
 DELTA/5.0 kt -----600m

- (b) *Extent of 1 psi overpressure.* For a 90 percent probability of precluding 1 psi overpressure enter figure VI-1 with $P = 100\%$ — $Q = 100\%$ — $90\% = 10\%$; $d/R_D = 1.24$. The required separation distance for each ADM in the allocation is listed below (table II-7):

$R_D \quad d = 1.24(R_D)$

ALFA/0.5 kt ----1050m 1300m
 BRAVO/1.0 kt --1325m 1650m
 DELTA/5.0 kt --2275m 2850m

- (e) *Step 5. Eliminate unsuitable ADM.*
 The ALFA/0.5 kt is eliminated

since it does not meet the coverage requirement ($f = 38\%$). In addition, the DELTA/5 kt is eliminated since its use would far exceed the commander's requirement to preclude 1 psi overpressure to the village north of the target.

- (f) *Step 6. Evaluation.* Only the BRAVO/1.0 kt is evaluated since all other ADM in the allocation have been eliminated. With this munition, displacement 50 meters south of target center is required to meet the 90 percent assurance specified for precluding 1 psi overpressure to the village. Displacing GZ 50 meters, coverage to the target is again computed:—

$$\begin{aligned} R_D/R_T &= 175/150 = 1.17 \\ d/R_T &= 50/150 = 0.33 \\ f &= 0.82 = 85\% \end{aligned}$$

Fallout is not expected to offset the operation since friendly units are upwind of the fallout effective wind direction and outside the one cloud radius distance from GZ.

By inspection, it is apparent that both troop safety and tree blowdown requirements are not affected by this displacement; therefore, further checks are not required.

- (g) *Step 7. Make recommendations.*

1. Type and yield:
BRAVO/1.0 kt/ADM
2. DOB:
Surface
3. GZ location:
50m south target center
4. Point of detonation:
N/A
5. Time of burst and option:
On order
6. Estimated results:
 $F = 0.85$ or 85 percent
7. Troop safety distance:
MSD (warned, protected; neg risk) 1400 meters

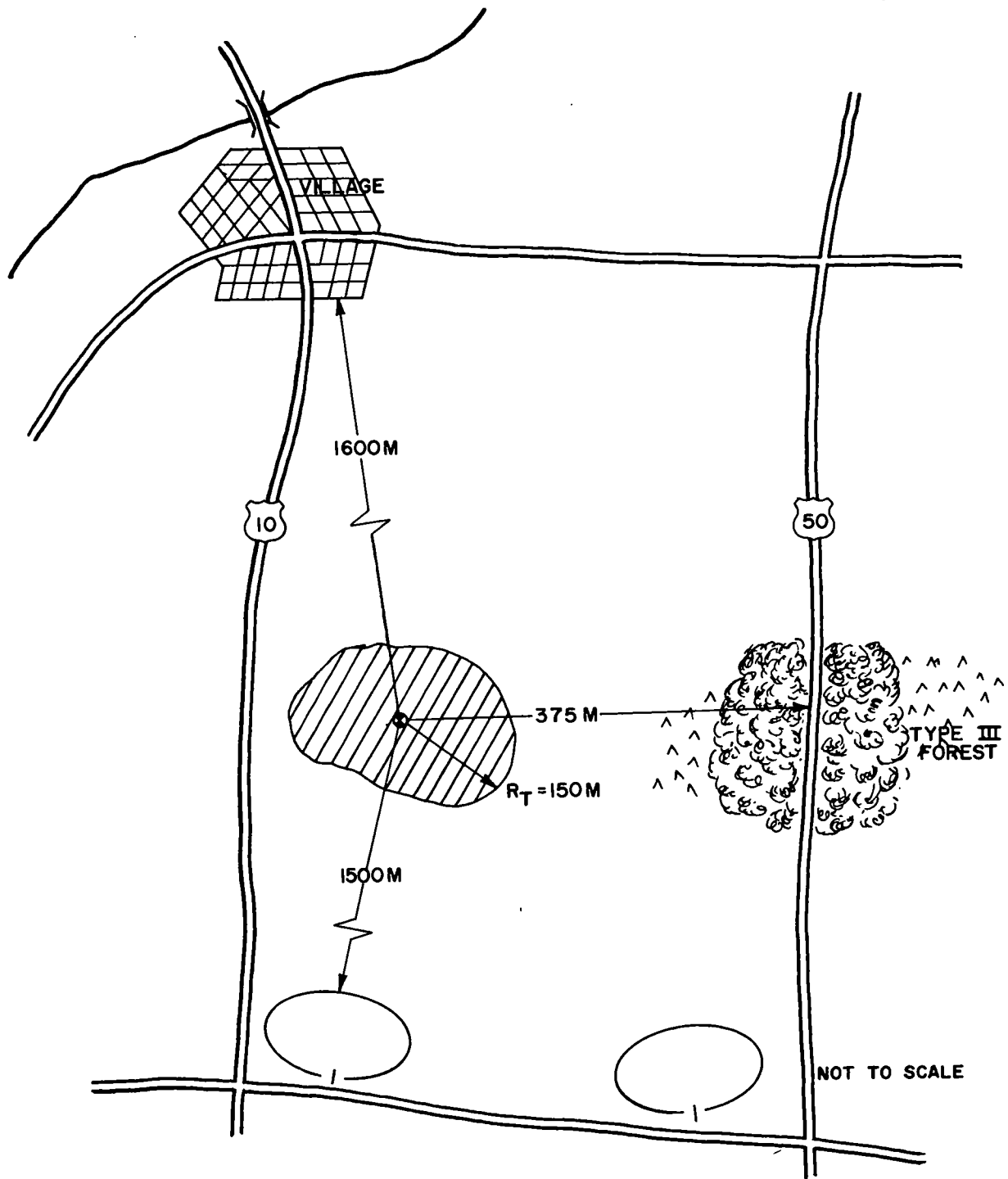


Figure VII-1. Sketch for example problem 1.

b. *Example Problem No. 2.*

- (1) *Given:* It is planned to employ ADM to assist a covering force in delaying the enemy's advance from the north until arrival of the main body. Friendly mechanized forces have taken up delaying positions on the high ground as shown in figure VII-2 and are in the FRRS radiation service category. The commander desires to use an ADM to crater the highway to include the width of clearing and to create tree blowdown as an obstacle to tracked vehicular movement in the adjacent type IV forest for a distance of at least 200 meters. The width of clearing is 24 meters and is underlain with soft rock. Friendly troops will be warned, protected; further, the SOP specifies negligible risk. The fallout effective wind is from the south. The ADM allocation includes the following:

- (a) SIERRA/0.01 kt/ADM.
 (b) VICTOR/0.10 kt/ADM.
 (c) ALFA/0.50 kt/ADM.

- (2) *Find:* Minimum yield ADM that will meet the stated requirements.

(3) *Solution:*

- (a) *Step 1. Identify pertinent information.*

1. *Target information.*

D_A (required) = 24 meters.

Radius of tree blowdown (required) = 200 meters.

2. *Friendly information.* The closest friendly troops are located 1400 meters from center of highway; these troops are warned and protected and negligible risk is specified.

- (b) *Step 2. Tentatively select point of detonation.* The center of the high is tentatively selected as the point of detonation. A surface burst (DOB = 0) is selected in view of the tree blowdown requirement.

- (c) *Step 3. Eliminate obviously un-*

suitable ADM. Weight or size limitations of available ADM impose no operational difficulty; therefore, none of the ADM are eliminated as *obviously* unsuitable.

(d) *Step 4. Determine data for:—*

1. *Estimating damage to the target.* In this case, a crater which covers the full width of clearing is desired. An examination of table II-3, Crater Dimensions, provides the following data:

	D_A	H_A
SIERRA/0.01 kt	----10m	2m
VICTOR/0.10 kt	----20m	4m
ALFA/0.50 kt	-----32m	7m

2. *Troop safety.* The distance from the tentative point of detonation to friendly lines is 1400 meters. Since troops are in the FRRS radiation service category the troop safety distances are read direct from table II-8, for negligible risk to warned, protected troops.

These distances are:—

SIERRA/0.01 kt	----- 900m
VICTOR/0.10 kt	-----1075m
ALFA/0.50 kt	-----1200m

3. *Bonus effects and limiting requirements.* Tree blowdown to prevent track vehicle movement extending at least 200 meters is required. Table II-6 indicates that tree blowdown (type IV forest) extends to the following distances:

SIERRA/0.01 kt	----- 75m
VICTOR/0.10 kt	-----135m
ALFA/0.50 kt	-----200m

- (e) *Step 5. Eliminate unsuitable ADM.* Since the SIERRA/0.01 kt and the VICTOR/0.10 kt do not provide a large enough crater, they are eliminated as unsuitable.

- (f) *Step 6. Evaluation.* There being

only one ADM that meets the stated requirements, no further evaluation is made.

(g) *Step 7. Make recommendations.*

1. Type and yield:
ALFA/0.5 kt/ADM
2. DOB:
Surface burst
3. GZ location:
Center of highway as shown on sketch

4. Point of detonation:
N/A
5. Time of burst and firing option:
On order
6. Estimated results
Crater ($D_A = 32\text{m}$ and $H_A = 6\text{m}$) plus tree blowdown extending 200 meters from GZ
7. Troop safety:
MSD (warned, protected; neg risk) 1200 mters

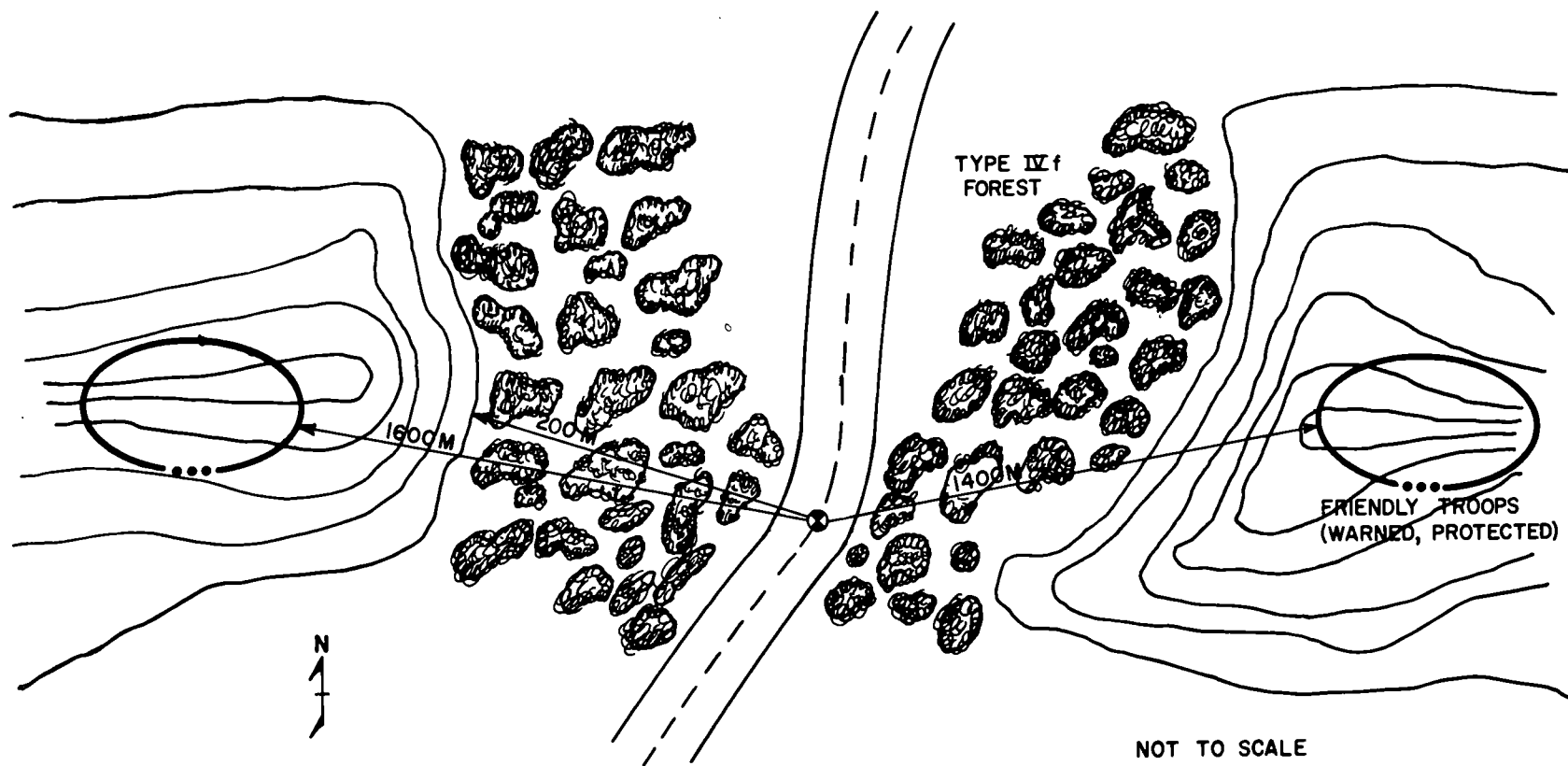


Figure VII-2. Sketch for example problem 2.

c. *Example Problem No. 3.*

- (1) *Given:* The commander desires to use ADM against a railway marshaling yard as part of the denial operation. Target reconnaissance reports show the yard as being roughly circular in shape; there is a turntable in the vicinity of target center; repair facilities, engine sheds, and rolling stock are uniformly distributed within an area 200 meters in diameter ($R_T = 100$ m); the target site is underlain with dry soil; there are several buildings of historical importance 500 meters from target center; the area in the immediate vicinity is heavily populated. The following command guidance has been given: Destruction of the railway turntable and 75 percent coverage (moderate damage) to repair facilities, engine sheds, and rolling stock is desired. Friendly troop units will not be in the area; however, the local population (warned and exposed) is not to be subjected to more than a negligible risk criteria for military personnel in a FRRS radiation service category. No more than light damage (1 psi overpressure) to the historical building is desired; if necessary, evacuation of local inhabitants to 1.6 kilometers from target center can be effected. The allocation includes one each of the following type ADM:
 - (a) VICTOR/0.1 kt/ADM.
 - (b) BRAVO/1.0 kt/ADM.
 - (c) ECHO/10.0 kt/ADM.
- (2) *Find:* The most suitable ADM, the location of ground zero, the HOB or DOB, the fractional coverage, and minimum safety distance for the local inhabitants.
- (3) *Solution:*
 - (a) *Step 1. Identify pertinent information.*
 1. *Target information.* The target consists of an area target ($R_T = 100$ m) which is composed of engine sheds, repair facilities, and rolling stock and a railway turntable which is a point target. The area is underlain with dry soil. In accordance with the unit SOP for preplanned targets, an effective wind speed of 15 km/hr is used to evaluate the effect of fallout.
 2. *Friendly forces.* Friendly troops will not be in the target area.
 3. *Command guidance.* Destruction of the railway turntable and at least 75 percent (moderate damage) target coverage is desired; negligible risk to local inhabitants (warned and exposed) is not to be exceeded; and no more than light damage (1 psi overpressure) to historical buildings located 500 meters from target center is desired.
 4. *ADM allocation.*

VICTOR/0.1 kt/ADM
BRAVO/1.0 kt/ADM
ECHO/10.0 kt/ADM
- (b) *Step 2. Tentatively select point of detonation.* Target center is tentatively selected as the ground zero location. Because of the stringent limiting requirements, a subsurface burst at optimum depth is tentatively planned to minimize the extent of both initial nuclear effects and fallout.
- (c) *Step 3. Eliminate obviously unsuitable weapons.* Weight or size limitations of available ADM impose no operational difficulty; therefore, none are eliminated as obviously unsuitable.
- (d) *Step 4. Determine data for:—*
 1. *Estimating damage to the target.*
 - (a) *Railway turntable.* Destruction of the railway turntable is assured if it is within the area defined by the apparent crater diameter. The mini-

imum yield VICTOR/0.1 kt/ADM provides an apparent crater diameter of 53 meters at optimum depth, thus all other ADM in the allocation meet this requirement.

- (b) *Engine sheds, repair facilities, and rolling stock.* Normally, airblast constitutes the governing effect against this type of target. At optimum depth, however, there will be a major reduction in airblast damage while cratering effects are maximized. Therefore, an estimate of damage to the above target elements based on the cratering mechanism is made. The radius of moderate damage is taken as the distance to which the crater lip extends. Within this area, damage to the target elements result from the combined action of ground uplift and the ejection of the soil from the crater (ejecta). From figure 6-1, the crater lip is found to be twice the apparent radius ($R_L = 2 R_A$); therefore, in computing target coverage, the R_D is equal to the apparent crater diameter ($R_D = D_A$). These values, (see table II-3) are noted and the coverage from each of the ADM in the allocation determined:

	DOB	$R_D = D_A$	R_D/R_T	f
VICTOR/0.1 kt/ADM	24M	53m	0.53	27%
BRAVO/1.0 kt/ADM	49M	106m	1.06	88%
ECHO/10.0 kt/ADM	97m	210m	2.10	99%

2. *Troop safety.* Troop units will not be in the target area at the time of detonation, however, the negligible risk MSD for warned and exposed personnel is determined (table II-8) for the benefit of the firing party and to assist in evaluating the hazard to the local inhabitants.

MSD*

- (a) VICTOR/0.1 kt/ADM --1,300m
 (b) BRAVO/1.0 kt/ADM --1,390m
 (c) ECHO/10.0 kt/ADM --1,500m

* Note. MSD are based on a surface burst. Reduction of safety distances for initial effects as a function of depth of burst cannot be quantitatively estimated at this time.

3. Limiting requirements.

- (a) *Negligible risk to local population.*

- (1) *Initial effects.* The MSD considering initial effects has been discussed in the above paragraph on troop safety.
- (2) *Fallout.* The local population will be considered safe if located outside of the predicted zone II fallout area. The distance to which this zone extends is determined using the procedure outlined in TC 3-15 and is based on a 15 km/hr effective wind speed.

	DOB	f	Scaled DOB
VICTOR/0.1 kt/ADM----	24m	2.0	48
BRAVO/1.0 kt/ADM-----	49m	1.0	49
ECHO/10.0 kt/ADM-----	97m	0.5	51

	Corr Factor	Zone I	Zone II
VICTOR/0.1 kt/ADM----	0.15	0.25km	0.5km
BRAVO/1.0 kt/ADM-----	0.15	0.65km	1.3km
ECHO/10.0 kt/ADM-----	0.15	1.80km	3.6km

- (3) *Maximum missile range.* The maximum missile range will not exceed the predicted Zone II fallout distance, but it may be significant upwind from the target. From figure 7-4 using a $DOB = 49 \text{ m/kt}^{0.3}$, the maximum missile range (d_m) is found to be $820 (W)^{0.3}$ meters. The various values for the ADM in the allocation are as follows:

	$W^{0.3}$	d_m
VICTOR/0.1 kt/ADM-----	0.50	410m
BRAVO/1.0 kt/ADM-----	1.00	820m
ECHO/10.0 kt/ADM-----	1.99	1640m

(b) *Damage to historical buildings.*

Using figure 7-1, the following values of overpressure at a range of 500 meters are obtained:

	DOB (m)	dob (m)	$r (m)$
VICTOR/0.1 kt/ADM---	24	52	270
BRAVO/1.0 kt/ADM---	49	49	282
ECHO/10.0 kt/ADM---	97	45	296

	$R_D (m)$	$P \%$
VICTOR/0.1 kt/ADM-----	124	0.00
BRAVO/1.0 kt/ADM-----	282	0.01
ECHO/10.0 kt/ADM-----	637	85

(e) *Step 5. Eliminate unsuitable ADM.*

The VICTOR/0.1 kt/ADM is eliminated since it does not meet the coverage requirement ($f = 27\%$). Also the ECHO/10.0 kt/ADM is eliminated because it does not meet the commander's guidance regarding the maximum missile range, the allowable overpressure to the historical buildings, and the acceptable limit of the predicted Zone II fallout distance.

(f) *Step 6. Evaluation.* Only the BRAVO/1.0 kt/ADM is evaluated since all other ADM in the allocation have been eliminated. With this munition placed at optimum burial of 49 meters, all conditions for coverage and limiting requirements are met considering that local residents are evacuated to a distance of 1,300 meters.

(g) *Step 7. Make recommendations.*

1. Type and yield:
BRAVO/1.0 kt/ADM
2. DOB:
49 meters
3. GZ location:
Target center
4. Point of detonation:
N/A
5. Time of burst and option:
On order
6. Estimated results:
Turntable destroyed plus 88 percent coverage
7. Safety distance:
(minimum distance to which civilians must be evacuated).
1,300 meters



S/Sch 1

CHAPTER 2

EFFECTS OF NUCLEAR EXPLOSIVES

Section I. GENERAL

2-1. Introduction

a. The employment of ADM requires a basic understanding of nuclear effects, particularly those resulting from subsurface bursts; the response of targets to these effects; the distance at which secondary damage or casualties may be expected; the influence of various environmental conditions; and the variability of predicted results.

b. This chapter presents a general qualitative discussion of the nuclear effects of ADM and their military significance; TM 23-200 should be consulted for details regarding specific nuclear phenomena.

2-2. Description of Nuclear Detonations

a. *Release of Energy.* Two types of nuclear reactions produce energy: fission and fusion. The energy released (yield) by either type reaction is measured in thousands of tons of TNT energy equivalent (kiloton or kt) or in millions of tons of TNT energy equivalent (megaton or mt).

b. *Energy Distribution.* Transfer of energy from an ADM detonation to the surrounding media begins immediately after detonation and is usually exhibited in four distinct forms—

- (1) *Blast or ground shock.* Mechanical shock effects are produced by a high pressure impulse or wave as it travels outward from the point of detonation (burst point).
- (2) *Thermal radiation.* Heating effects result as objects in the surrounding area absorb thermal energy released by the burst.
- (3) *Nuclear radiation.* Ionization of the surrounding media occurs when nuclear radiation emitted by the burst is absorbed.

- (4) *Cratering.* Material near the munition is crushed, fractured, and displaced with large quantities being ejected beyond the immediate area of the point of detonation.

2-3. Damage Criteria and Radius of Damage

a. *General.* Data pertinent to the military employment of nuclear explosives have been developed through tests. These include:

- (1) The blast and thermal radiation levels required to cause a particular degree of damage to materiel targets.
- (2) The distance to which the required levels of damage extend from a given point of detonation and/or ground zero.

b. *Damage Estimation.* The prediction of the condition of a target after it has been attacked is termed damage estimation.

c. *Degrees of Damage.* Damage to materiel targets is classified as severe, moderate, or light. These degrees of damage are described as follows: (for further details, see app. III:)

- (1) *Light damage* does not prevent the immediate use of an item although minor repair may be required to make full use of the item.
- (2) *Moderate damage* prevents use of an item until extensive repairs are made. This degree of damage is normally sufficient for most denial type targets composed of military equipment or supplies.
- (3) *Severe damage* permanently prevents use of the item. Repairs in this case is generally impossible or more costly than replacement. Normally, this is the criterion for hard targets such as field fortifications, dams, or bridges.

d. *Radius of Damage.* The radius of damage (R_D) is the distance to which a specific effect extends. For each yield and point of burst, the R_D varies with the degree of damage desired and the type target. *For example*, the R_D for moderate damage to wheeled vehicles differs from that for severe damage as does the R_D for severe damage to field fortifications. A detailed discussion of predicted target coverage is contained in FM 101-31-1.

2-4. Types of Bursts

Nuclear detonations may occur at any point from deep below the earth's surface to high in the atmosphere. Tactically, nuclear bursts are classified according to the manner in which they are employed; that is, air defense, high air, low air, surface, and subsurface. Types of burst normally applicable to ADM employment are subsurface and surface bursts.

a. *Subsurface Burst* (less than zero height of burst). This type of burst is used to cause damage to underground targets and to maxi-

mize cratering effects. The subsurface burst provides flexibility for the control of both initial and residual nuclear effects, along the surface or in the atmosphere. *For example*, at optimum depths of burial for cratering, thermal radiation is eliminated, initial nuclear radiation and airblast are severely curtailed, and downwind distance of zones I and II for fallout are reduced to approximately ten percent of that from a surface burst; moreover, in the case of subsidence craters (surface cave-in), nuclear effects on the surface are virtually eliminated.

b. *Surface Burst* (zero height of burst). This type of burst occurs when an ADM is detonated at ground level. This type burst is used to destroy targets susceptible to high blast overpressures, thermal radiation, cratering, and ground shock. Whenever fallout is not a limiting factor, the surface burst may be used; however, if fallout is desired as a bonus effect, slightly burying the ADM significantly enhances the fallout produced.

Section II. BLAST

2-5. Airblast and Ground Shock

Airblast accompanies all types of bursts except for a completely contained detonation.

a. An airburst produces a slightly greater radius of damage against targets vulnerable to low overpressures than would an equivalent-yield surface burst.

b. A surface burst, however, is more effective against most military *demolition targets* because of the immediate reflection and reinforcement of the blast wave by the earth's surface, thereby resulting in greater ranges for *high* overpressures.

c. A subsurface burst produces the least blast damage to military targets above ground since the major part of the total energy is used in cratering or is transmitted as ground shock. The deeper the ADM is emplaced, the less air blast is produced. Chapter 7 discusses reductions in blast damage radii for various depths of burial.

2-6. Damaging Pressures

As the blast wave moves outward in all directions, it exerts two types of damaging pressures on materiel targets in its path:

a. *Overpressure.* This is a squeezing or crushing force which surrounds the object and continues to apply force from all sides until the pressure returns to normal. At any given point away from ground zero, the highest overpressure reached during passage of the blast wave is called the peak overpressure for that point. Targets which are sensitive to and are damaged primarily by overpressures are called *diffraction targets*.

b. *Dynamic Pressure.* As the blast wave moves away from the burst point, it is accompanied by high winds. Dynamic pressure is a measure of the forces associated with these winds. This pressure causes damage by pushing, tumbling, or tearing apart target elements. Targets which are damaged by dynamic pressure are called *drag-type targets*. Most materiel targets are drag-sensitive.

c. *Firing Options.* Once emplaced, each ADM of the hypothetical family is considered to have a remote, on-call firing capability as well as a timer option. When using timer option, the time of detonation may be varied in 10-minute increments from 10 minutes to 1 hour and in 30-minute increments to 12 hours. Accuracy of the timer is assumed to be ± 5 minutes per hour of time set on the timer (para. 4-12).

d. *Subsurface Capability.* ADM of the hypothetical family are assumed to have both an underground and underwater capability. Underground burial is limited to 10 meters (33 ft) of backfill which is tamped material replaced directly on top with no protective shielding of the ADM. Underwater detonation is possible in depths up to 30 meters (100 ft). If greater depths are desired, special adaptive devices are required to protect the munition from excessive overhead pressure.

e. *Separation Distance.* To insure that one emplaced ADM is not damaged by the detonation of another in the same general target area, it is assumed for the hypothetical family that a separation distance of 1000 meters (3300 feet) between ADM detonations on the surface is required for all yields. For subsurface bursts near optimum depths, this distance may be reduced by one-half.

f. *Residual Radiation.* Residual radiation is an important consideration in the employ-

ment of ADM. This aspect of ADM employment from a troop safety standpoint is discussed in chapter 7.

3-6. Response Time

In addition to the design characteristics of ADM, the time necessary to analyze the target, secure the emplacement site, deliver and prepare the ADM for firing, emplace the munition, and warn friendly units significantly affects the manner in which ADM are employed. As a basis for general tactical planning, 2 hours is assumed to be the average time for a reasonably well-trained ADM team operating in daylight under favorable conditions to prepare and emplace a hypothetical ADM with remote options on the surface or in a previously prepared position. If only timer option is used, planning time may be reduced to 1 hour. Blackout operations, enemy interference, elaborate emplacement techniques, or severe weather conditions may considerably extend this period. Moreover, transportation time to the emplacement site is in addition to the above stated times. Obviously, each target presents varied circumstances which affect response time and require individual consideration prior to ADM employment. Nevertheless, response time may be materially reduced by thorough training and the establishment of effective ADM standing operating procedures (SOP).

Section II. COMMAND AND STAFF PROCEDURES

3-7. General

Planning for the employment of ADM involves the same command and staff procedures normal to planning any tactical operation. The command, intelligence, operational, and logistical procedures are carried out concurrently rather than sequentially. ADM missions are implemented by plans and orders formulated under the guidance of the tactical commander during staff planning.

3-8. Allocation of ADM

a. Because of the combat potential afforded by ADM and their limited number, the com-

mander carefully controls the supply, expenditure, and resupply of this type munition. ADM fall into the category of special ammunition, which is ammunition specially designated by the Department of Army because of unique requirements in control, handling, and security.

b. An allocation of ADM is the apportionment of a specific number of complete ADM to a commander during a specified period of time as a planning factor for use in the development of plans. Additional authority is required for actual dispersal of allocated ADM to locations desired by the commander to

support his plans. A commander cannot authorize the expenditure of an ADM unless he has a release by proper, competent authority or is disposing of it in compliance with emergency disposal standing operating procedures. Procedures for disposition of excess ADM are found in FM 9-6.

c. The duration of the allocation periods are generally dictated by the commander's concept of the operation. He allocates ADM for the period during which he can visualize the operation. He retains ADM in reserve for those periods that he cannot visualize, i.e., for employment against targets of opportunity and for use during later phases of the allocation period. The duration of an allocation period differs at each echelon of command. The field army commander may be allocated ADM for a longer period than the corps commander and the corps commander for a longer period than the division commander.

d. Reserve maneuver forces receive only a planning allocation until committed; at this time, they may be assigned a portion of the reserve allocation.

e. A commander who allocates ADM to a subordinate command may withdraw or change that allocation as required. Reduction in an allocation is made only when absolutely essential and with as much prior notification as possible.

3-9. Command Guidance

a. The magnitude and nature of nuclear effects have a profound influence on ground operations. Therefore, command guidance to the staff before commencement of planning is essential. If there is little time for staff planning, this guidance may consist of an immediate decision by the commander to employ ADM. When more time is available, the guidance may include specific courses of action for staff consideration during the development of staff estimates.

b. In developing his initial staff planning guidance, the commander considers the requirements of all the general staff. In addition, he provides guidance for the staff en-

gineer, the artillery commander, the chemical officer, and other concerned staff officers. The commander provides additional guidance as required throughout all planning phases up until the time the ADM mission is executed.

c. It is essential that commanders and staff officers generally understand the capabilities and limitations of ADM, the combat service support requirements involved, and the procedures for employing these munitions. These officers receive technical advice from nuclear weapons employment officers (NWEEO) and engineers on matters relating to the use of ADM.

d. Initial staff planning guidance normally falls into the following categories: type of targets, allocation to subordinate units, desired ADM reserve, and acceptable degree of risk for civilian populations in the area. The commander's initial staff planning guidance for ADM employment varies in content with the echelon of command. Damage criteria and troop safety considerations are matters of standing operating procedures (SOP). Command guidance in these respects is appropriate only when departure from SOP is desired. Based on the SOP, the nuclear weapons employment officer and engineer determine the extent and nature of the damage desired and recommends the ADM best suited for that task. Similarly, the commander designates, whenever possible, negligible risk for his own and adjacent forces. The staff, without further direction, takes this into account in their operational planning. If greater than negligible risk must be taken or if friendly troops must be warned, the nuclear weapons employment officer includes this information as part of his recommendations. Creation of obstacles to friendly movement and similar undesirable effects are also matters of SOP not normally requiring specific guidance to the staff and nuclear weapons employment officers.

3-10. Staff Responsibilities

a. In planning the employment of ADM, certain specific responsibilities are allocated to the general and special staff. Coordination

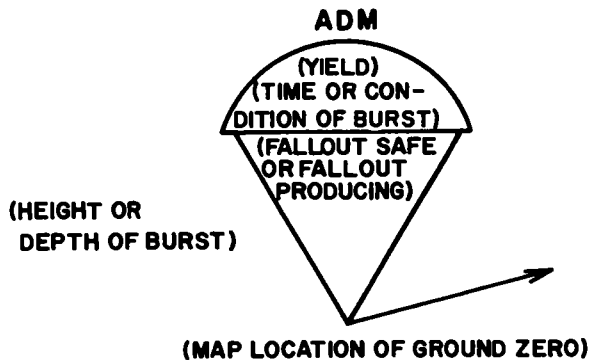
tion plan in close coordination with the staff engineer and fire support element. When approved by the commander, the atomic demolition plan may be verbally announced; transmitted electrically; or published as an appendix to the barrier plan annex, an appendix to the engineer annex, or an appendix to the fire support annex. When published as an appendix to the barrier plan annex, the atomic demolition plan need only be referenced in the engineer and fire support annexes. The atomic demolition plan contains the information necessary for subordinate units to prepare their supporting plans (app. IV).

b. The atomic demolition plan is normally prepared in detail for *preplanned* targets only. An atomic demolition plan contains as a minimum—

(1) Target locations and descriptions.

- (2) Model and yield of ADM, points of detonation, and locations of ground zero.
- (3) Units to be designated task responsibility for each ADM mission.
- (4) Firing options.
- (5) Times of emplacement and final arming, if applicable.
- (6) Times or conditions for execution of each target, if applicable.
- (7) Authority to arm and fire each ADM.
- (8) Authority to change or cancel each mission or to institute emergency ADM evacuation or destruction.

c. The atomic demolition plan may be partially prepared and transmitted in overlay form utilizing conventional ADM map symbols illustrated in figure 3-3.

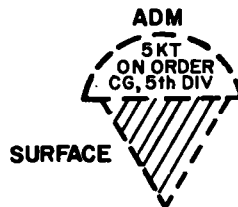


NOTE: SYMBOL IS GREEN
FOR BOTH ENEMY
AND FRIENDLY ADM.

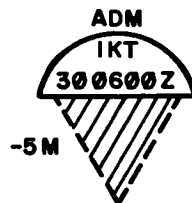
DIRECTION OF PREVAILING
WINDS AT TIME OF BURST
(OPTIONAL)

DESCRIPTION

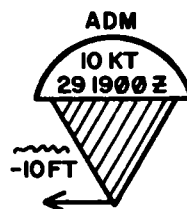
1. Proposed surface burst ADM (dotted lines), 5 KT, fallout producing (shaded stem), to be detonated on order of the Commanding General, 5th Division.



2. Emplaced but not detonated ADM (dotted stem), 1 KT, minus 5 meters underground, fallout producing, to be executed on the 30th of the month at 0600Z hours.



3. Executed ADM (solid lines), 10 KT, minus 10 feet underwater (below wave line), fallout producing, easterly prevailing wind, detonated on the 29th of the month at 1900Z hours.



4. Executed enemy ADM (double head), approximately 0.5 KT (brackets), fallout safe (no shading in stem), minus 200 meters underground, detonated on the 28th of the month at 1400Z hours.

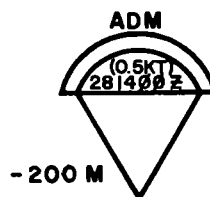


Figure 3-3. ADM conventional map symbols.

guard) to provide local security for the mission and prepares the orders to the demolition guard commander and the commander of the demolition firing party (STANAG 2017, app. IV). Communications are provided to insure adequate control of the mission; in addition, the executing commander may appoint a liaison agent as his representative to supervise target execution. The executing unit has the added responsibility of warning friendly units and civilians in the target area. Such responsibility encompasses control of traffic and refugee flow; and, if warranted, military and civilian exacuation of danger areas (FM 19-25). Lastly, the executing commander provides the releasing commander with changes in the state of ADM readiness, munition expenditures, and tactical damage evaluation reports.

3-19. Demolition Guard Commander

a. Upon designation as demolition guard by the executing unit commander and attachment of an ADM capability, the demolition guard commander assumes responsibility for the assigned ADM target and local security of the ADM. The composition and size of the demolition guard varies in accordance with the tactical situation.

b. In most cases, the demolition guard requires engineer support to accomplish the ADM mission. At the very minimum for hasty demolition, such assistance is composed of an engineer ADM firing party. For more deliberate demolitions, additional engineers and equipment to assist in emplacement are necessary. The means for actually detonating the ADM (i.e., the ADM firing party) are attached to the demolition guard for the duration of the mission. Attachment facilitates command and control and insures that clear-cut command lines for detonation of the ADM are established. Other engineers engaged in support of the mission, such as emplacement site preparation, need not be attached; they perform their tasks in direct support of the demolition guard, provided adequate coordination of effort is maintained.

c. The demolition guard commander relays

the orders of the executing headquarters to the demolition firing party commander. One order, referred to as the ADM firing order, is prepared by the executing unit in conjunction with the orders to the demolition guard for each target and contains necessary instructions for target demolition. Whenever possible, a written ADM demolition order follows a format which parallels, although it does not duplicate, the conventional demolition firing order standardized by STANAG 2017 (app. IV).

d. After the munition is armed, the demolition guard commander or his representative and the demolition firing party commander remain at the command site. Depending on the urgency of the target, the order for target demolition may follow normal command channels or may be established directly with the releasing commander and/or the executing headquarters (fig. 3-5). If such communications are established, the demolition guard assumes the role of a separate demolition task force.

e. The demolition guard commander is responsible for the local security of the emplacement and command sites and the evacuation of the demolition guard and firing party prior to detonation. Upon occupation of the area, outposts are established to provide all-around security; and observation and listening posts are organized to give early warning of an enemy advance. Liaison is accomplished with adjacent units, and the security of the ADM emplacement and command sites is coordinated with existing defenses in the area. The demolition guard insures that the routes of evacuation and areas designated to provide protection from the effects of ADM are disseminated to all members of the demolition guard, demolition firing party, and friendly units through which withdrawal is contemplated.

f. Lastly, the demolition guard commander is responsible for keeping the executing headquarters informed of the tactical situation at the target site and the state of readiness of the ADM. After detonation, a tactical damage evaluation report is rendered based on target

damage reported by the demolition guard commander. In the event of a misfire or partial destruction of the target, the demolition

guard commander immediately initiates steps to complete target destruction by other means within his capabilities.

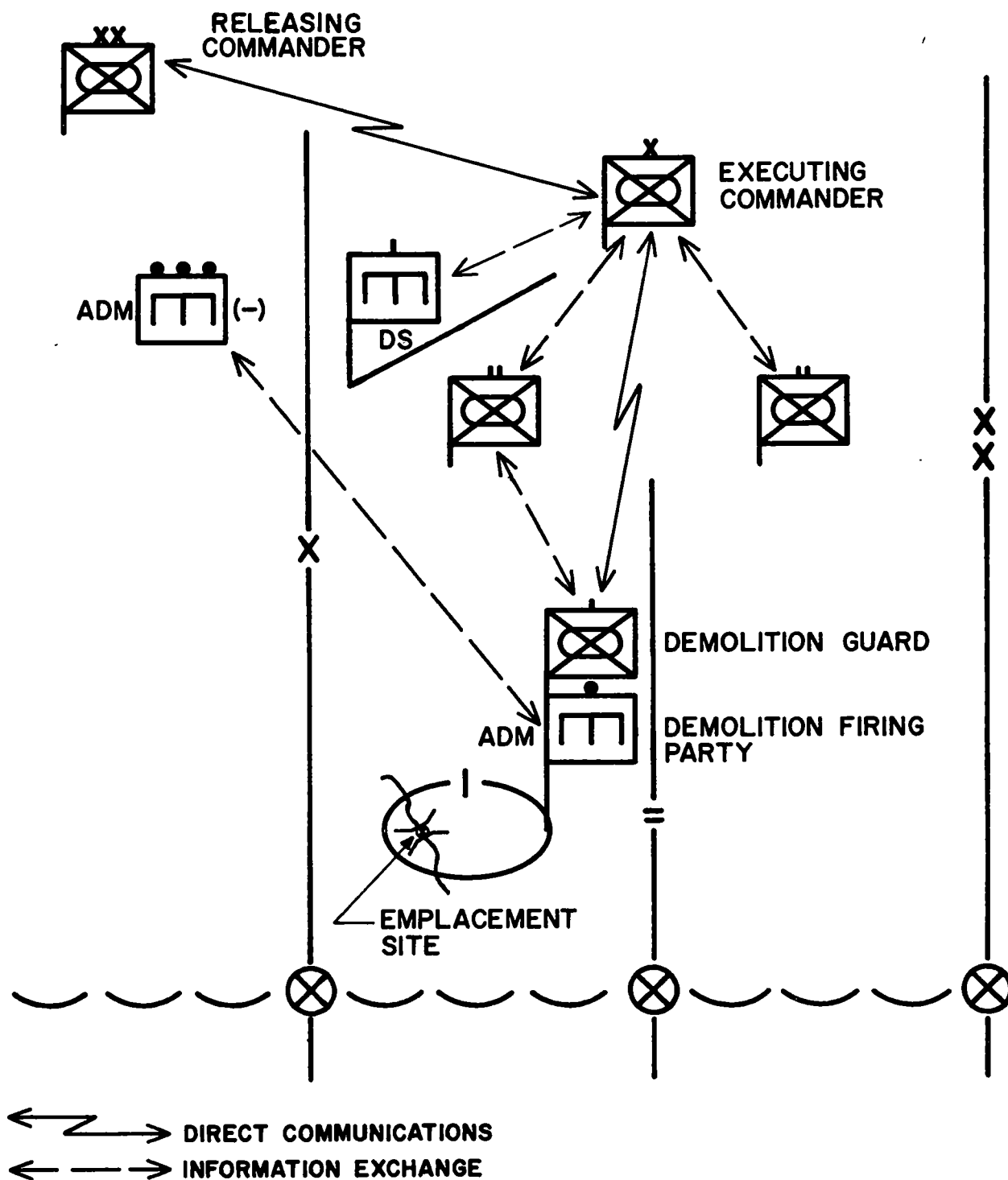


Figure 3-5. Communications for a typical ADM target.

3-20. Demolition Firing Party Commander

a. The demolition firing party is normally composed of all ADM team members attached to the demolition guard. One demolition firing party is assigned to each target to install and detonate the munition.

b. The demolition firing party commander, who is senior ADM team member, is limited in action by the instructions contained in the ADM demolition firing order. He may recom-

mend change but not alter the state of readiness of the ADM or site location without specific instructions from the demolition guard commander. Instructions to fire the ADM must be stringently followed to insure that the target is destroyed at the prescribed time, thus avoiding friendly casualties from ADM effects. Moreover, the demolition firing party commander acts as the technical adviser for the demolition guard commander.

Section IV. WARNING, LOGISTICAL, SECURITY, AND SAFETY PROCEDURES

**3-21. Warning of Friendly ADM
Detonations**

a. Advance warning of ADM detonations is required to insure that friendly forces and civilians are not subjected to casualty-producing nuclear effects. When an ADM is preplanned, there is usually adequate time to alert personnel in areas where significant effects may be received. On the other hand, when ADM are employed against targets of opportunity, a standing operating procedure is required which permits rapid notification of personnel who could be affected by the detonation. The difficulty of warning all personnel can be appreciated if the various concurrent activities in the combat zone are visualized. Messengers, wire crews, litter bearers, aid men, and engineer work parties move about frequently in the performance of their duties and are often not in the immediate vicinity of troop units when warning of impending nuclear employment is issued.

- (1) Notification concerning friendly nuclear employment is a time-consuming process unless procedures are carefully established and rehearsed. On the other hand, dissemination of warning earlier than necessary may permit the enemy to learn of the operational plan.
- (2) When there is insufficient time to warn personnel within the limit of visibility, only those who may receive tactically significant nuclear effects

are warned. Generally, there is no requirement to warn subordinate units when target analysis indicates that there is no more than a negligible risk to unwarned, exposed troops. Dazzle to ground troops need only be considered in night operations.

- (3) Aircraft, particularly army aircraft, can be damaged by low blast overpressures. Likewise, dazzle is more significant to personnel operating aircraft than to personnel on the ground. Because aircraft can move rapidly from an area of negligible risk to an area where damaging nuclear effects or dazzle may be encountered, all aircraft within the area of operations are given advance warning.
 - (a) Army aircraft are warned through the appropriate air traffic control facility or through the unit command net.
 - (b) Navy and air force aircraft are warned through Navy and Air Force channels. At corps and division level, the notification of planned nuclear employment is transmitted to other services through the navy or air force liaison officer; at field army level, this notification is accomplished through the Air Support Operations Center (ASOC).

- (4) When employing very low yield nuclear detonations against targets of opportunity, some relaxation of the requirement for positive warning may be authorized.

b. Nuclear employment warning messages are disseminated as rapidly as possible. The requirement for speed is frequently in conflict with a requirement for communication security. Authentication procedures and encoding instructions for nuclear strike warning messages are included in unit signal operations instruction (SOI).

- (1) The amount of information to be encoded is held to a minimum in order to expedite dissemination.
- (2) Message items DELTA and FOX-TROT (app. VIII.) will not be sent in the clear unless insufficient time remains for the enemy to react.

c. Nuclear warning messages are given a precedence of FLASH.

d. The zones of warning, protection requirements for personnel located in any of the warning zones, and the content of a nuclear warning message (STRIKWARN) are prescribed by STANAG 2104 which is reproduced in appendix VIII.

e. All available communication means are used to rapidly disseminate nuclear warnings.

f. A fragmentary warning order may be issued while an ADM mission is being processed to alert units that are in an area where they may receive nuclear effects.

g. Procedure for friendly nuclear detonation warning.

- (1) Warning responsibilities.
 - (a) Responsibility for issuing the initial warning rests with the commander requesting the nuclear detonation.
 - (b) Commanders authorized to release nuclear detonations will insure that detonations affecting the safety of adjacent and other commands are coordinated with those commands in sufficient time to permit dissemination of warnings

to friendly personnel and the taking of protective measures. Conflicts must be submitted to the next higher commander for decision.

- (2) The commander responsible for issuing the warning should inform—
 - (a) Subordinate headquarters whose units are likely to be affected by the detonation.
 - (b) Adjacent headquarters whose units are likely to be affected by the detonation.
 - (c) Own next higher headquarters, when units not under the releasing commander are likely to be affected by the detonation.
- (3) Each headquarters receiving a nuclear warning message will warn subordinate elements of the safety measures they should take in light of their proximity to the DGZ.
- (4) Unit SOP's should require that STRIKWARN messages be acknowledged and there should be common understanding as to the meaning of the acknowledgement; e.g., all platoon-size units in the affected area have been warned.

3-22. Distribution of Atomic Demolition Munitions

a. Commanders and staff officers continuously evaluate the capabilities and limitations of logistical systems to support nuclear employment. Because of the destructive nature and limited availability of nuclear munitions, distribution is an operational as well as a logistical problem.

b. The nuclear munition logistical system is designed to operate in different tactical situations, forms of warfare, and operational environments. Commanders and staff officers concerned with planning and controlling special ammunition support activities consider the following requirements:

- (1) Continuous nuclear logistical support of tactical operations.

- (2) Simplicity and uniformity in procedures.
- (3) Minimum handling of nuclear ammunition.
- (4) Security of classified or critical material and installations.

c. The specific quantity of special ammunition to be carried by a unit is termed the prescribed nuclear load (PNL). The specific quantity of various special ammunition items to be stocked in an ordnance unit or installation is termed special ammunition stockage (SAS).

d. A commander controls the distribution of ADM by—

- (1) Determining the number of ADM which organic or attached units under his control will carry as part of their PNL.
- (2) Designating any ADM from his own allocation or the allocation of a higher commander which he desires to have carried in the PNL of a unit that is under the control of a subordinate commander. This PNL may contain ADM to support the allocation of the subordinate commander as well as those to be delivered to support the allocation of the higher or adjacent echelon.
- (3) Coordinating the stockage of ADM as part of the SAS of a special ammunition installation not under his control; directing the ADM stockage in special ammunition installations under his control.

e. The positioning of ADM for security and operational purposes may result in a commander having more ADM carried by his emplacement units than he is authorized to fire. He may also have fewer ADM within his command than he has been allocated. In the latter case, procedures are established by which the additional ADM can be quickly obtained when required.

f. When the availability of ADM permits, consideration is given to placing them in all engineer emplacement units. ADM may be so

dispersed before allocations are announced. In some cases, this procedure permits greater responsiveness once unit allocations are announced.

g. Replenishment of PNL and SAS is accomplished by directed issue, automatic issue, or a combination of both. Because of the limited supply and the movement of ADM to meet the changing tactical situation, directed issue is most practical. If a relatively large number of ADM of a specific type and yield is available, a commander may direct that engineer units under his control replenish their PNL automatically as expenditures occur. The method of replenishment should be covered in the SOP.

h. Distribution of ADM is affected by—

- (1) Mission.
- (2) Allocation, current and anticipated.
- (3) Munition availability.
- (4) Carrying capacity of emplacement units.
- (5) Security.
- (6) Transportation capability of support units.

i. Nuclear munitions are stored and issued to ADM teams by special ammunition units. Issues are made using supply point distribution procedures. The details of ammunition service are contained in FM 9-6.

3-23. Tactical Accountability

The decisive character of nuclear weapons and their limited availability make detailed accounting necessary. Information pertaining to ADM location, allocation, and expenditure is made available to the members of the TOC, the artillery fire direction center, and the staff engineer. In addition, the TOC and the engineer need information on ADM readiness status, operational capabilities of engineer emplacement units, and the travel time between logistical and tactical locations. This information is maintained in a manner to permit ready display to the commander and staff officer. Suggested forms or methods by

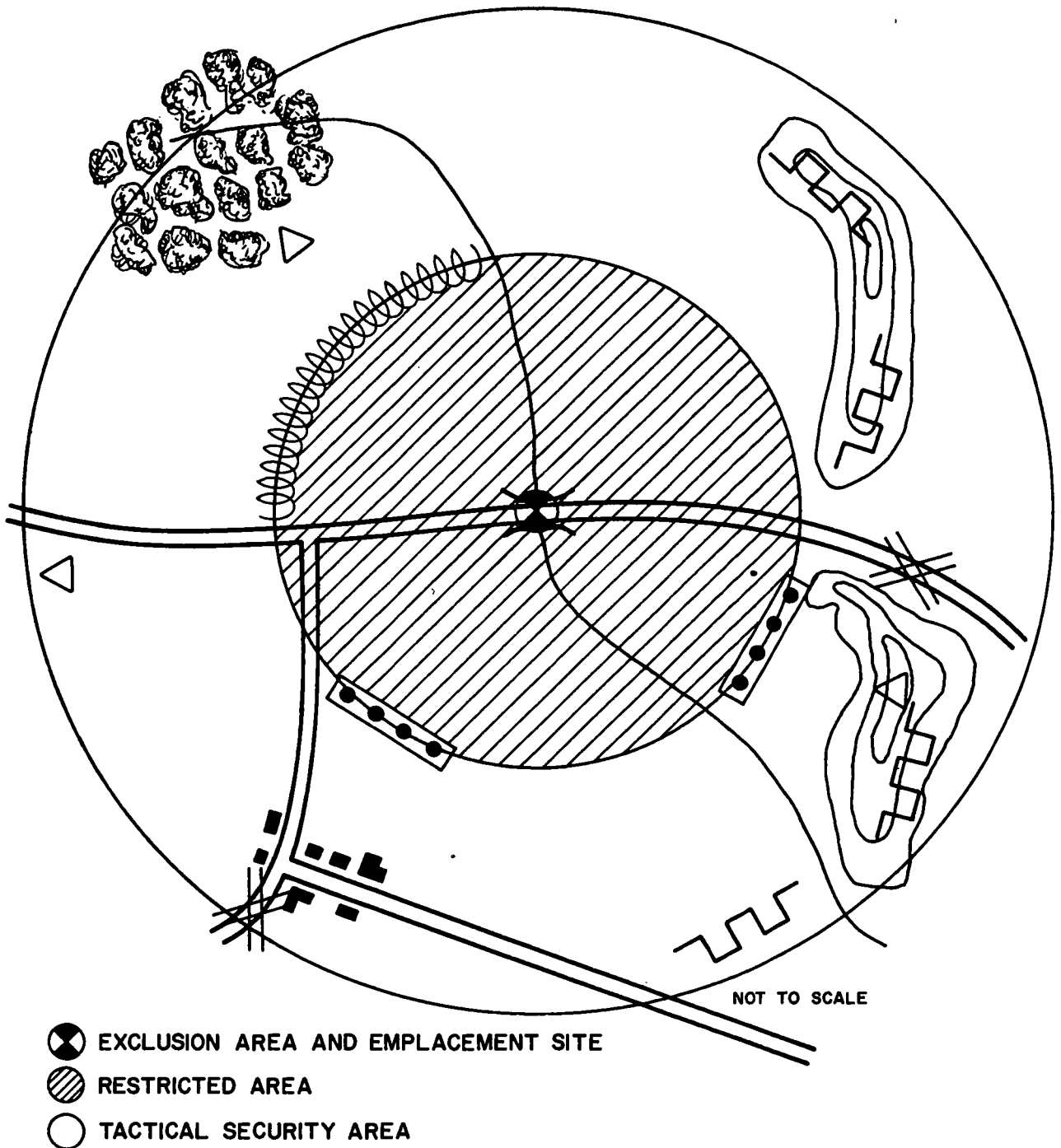


Figure 3-6. Security of an ADM emplacement site.

3-25. Safety

a. Safety is a continuing function of command. ADM, like other demolition materials,

involve potential danger. The safety of troops and other personnel is of primary importance. Safety rules are mandatory for peacetime

operations during operational readiness maneuvers, exercises, and training; no deviation is authorized. Safety rules are promulgated by Department of Army letters and disseminated through appropriate command directives. Their purpose is to incorporate the maximum safety consistent with operational requirements.

b. If there is an accident involving ADM, the commander having possession of the munition at the time of the accident is responsible for notifying emergency teams to assist in rescue, recovery, and damage assessment. Explosive ordnance disposal (EOD) units of the ammunition service structure should be called upon to render safe, recover, and dispose of unexploded munitions or, in the event

of a low-order detonation, to recover and dispose of classified components and radioactive materials. There are specific actions to be taken and reports to be rendered in the event of an accident or incident involving ADM. ADM team safety activities are stated in the technical manuals for each munition, in associated safety publications, and in the unit SOP.

c. Temporary storage safety is governed in general by the quantity safe distance criteria which govern the temporary storage of high explosive and nuclear materials. Particular storage requirements for each demolition are covered in the prefire manual for that munition.

acteristics of the specific target are recorded, the reconnaissance team proceeds to investigate the surrounding area for other elements that may be affected by the burst. The location or proposed location and type of protection afforded to friendly troops in the vicinity of ground zero is vital in planning ADM missions. Other considerations such as the location of nearby forests or population settlements may also be of importance. In cratering, soil type is of critical significance as well as the proximity of bypasses which may reduce an obstacle's effectiveness. Chapter 6 outlines the specific information upon which detailed target analysis is based.

c. Command sites and alternate command sites are selected during reconnaissance (para 4-21). Concealed routes of withdrawal to areas of protection against nuclear effects are also selected for the demolition guard and firing party. Each route is reconnoitered and the withdrawal time noted.

d. If emplacement holes or other emplacement methods beyond the capabilities of ADM teams are required, such information together with an estimate of the number and type of engineers, equipment, and time necessary to prepare the target for demolition is recorded. When aerial delivery of ADM is contemplated, suitable landing areas are also reconnoitered and reported by the reconnaissance party.

e. To facilitate a uniform method of recording and reporting potential ADM targets, reconnaissance forms similar to that shown in appendix IV may be locally produced. Such forms provide uniformity in reporting target information and are designed for electrically transmitted as well as written reports.

4-7. Engineer ADM Training

a. Schools for training ADM specialists have many facilities and aids that are difficult or impossible to duplicate in the field. Engineer units obtain and utilize school-trained personnel whenever possible. Moreover, unit training in coordinated ADM operations must be continuously conducted. On-the-job training is required to develop proficiency in technical procedures and to provide additional

qualified specialists. On-the-job training conducted by units should make maximum use of standard and expedient training equipment and school-published training materials to enhance instruction. Personnel must be given instruction on the unit ADM SOP as well as their individual specialties. Unit training records are maintained as a basis for periodic refresher training.

b. Specially skilled personnel and special equipment may be required to support the prefire team by the preparation of the emplacement and command sites. Practical exercises in these functions provide excellent training for personnel involved. The organization of an ADM demolition firing party to accomplish the above support functions and the prefire operations should be included in the unit SOP. Within the prefire element, individuals should be cross trained in all test and prefire procedures to provide depth and, thereby, insure that the team will function efficiently in the event of casualties.

c. In addition to normal training records, engineer units maintain ADM training records. These records reflect the names of personnel qualified to perform prefire and test procedures, their security clearances, their type of training (school trained or unit trained), manuals available in a current ADM reference file, and whether or not personnel have read appropriate manuals and changes.

d. Inspections should be conducted to determine the technical proficiency of personnel and to evaluate other factors affecting the unit's ability to conduct ADM missions. To better determine a unit's ability to deliver and emplace ADM reliably, technical proficiency inspections (TPI) should be conducted as a phase of field exercises. Such exercises, conducted under conditions similar to those expected to be encountered in an actual mission, provide a basis for determining the unit's ability to perform the following:

- (1) Pickup, handling, transporting, and storing munitions.
- (2) Partial storage monitoring.
- (3) Unpackaging and repackaging procedures.

- (4) User maintenance.
- (5) Prefire and test procedures.
- (6) Procedures for delayed or cancelled missions.
- (7) Emplacement procedures.
- (8) Accident and incident control and reporting.
- (9) Troubleshooting procedures.
- (10) Preparation and maintenance of records and reports.
- (11) Safety and security procedures.
- (12) Emergency destruction procedures.

4-8. Transportation of ADM

During transport, engineer personnel normally accompany ADM from the special ammunition supply point (SASP) to the emplacement site. Practically any vehicle of suitable capacity can be used, including army aircraft or boats, and, for some munitions, pack animals or men. Transportation requirements must include lifting and loading equipment for handling the larger munitions. Wreckers, cranes, rail systems, or fabricated ramps are some expedients that may be used. Tactical security considerations determine the vehicular convoy composition and the strength of the security forces necessary for escort. The overall command of the convoy may be specified in the orders to the demolition guard commander or in the engineer unit ADM SOP. To insure reinforcement in case of an emergency, the convoy commander maintains continuous communication with higher headquarters.

4-9. Storage and Maintenance

a. Depending upon the disposition of ADM, engineer units may be directed to carry ADM as prescribed nuclear loads (PNL).

b. Temporary storage of war reserve ADM must meet the requirements listed in appropriate technical manuals and army regulations (app. I). These requirements are for war reserve ADM only and do not pertain to unclassified training items or simulated munitions used for exercise purposes. Except in

emergency, ADM are not stored until these facilities are available. However, in fluid tactical situations, increased reliance is placed on the use of armed guards instead of fixed installations.

c. Engineer units having custody of ADM are responsible for certain inspection and maintenance duties. Inspections are generally limited to partial storage monitoring in accordance with the instructions contained in applicable technical manuals (app. I). The engineer unit may request advice and assistance from special ammunition units. Also the engineer unit SOP should provide general guidelines in both storage and maintenance procedures.

4-10. Test and Prefire Procedures

The time required to test and prefire an ADM depends largely upon the proficiency of the demolition firing party. To reduce time required at the emplacement site, as many test and prefire operations as possible are performed in a secure rear area. Thereafter, the munition is handled and transported with extreme care so that tests are not invalidated or the munition rendered unreliable. Detailed prefire procedures are contained in the technical manuals for each munition (app. I).

4-11. Emergency ADM Denial

a. To prevent the enemy from capturing ADM intact or reconstituting munitions by cannibalization, emergency denial operations may be authorized. Emergency denial is considered as part of ADM mission planning. Authority to implement emergency denial must be clearly stated in the unit SOP and ADM team members must be thoroughly trained in emergency destruction methods. Methods of denying munitions and related materiel are—

- (1) *Evacuation*—the safing and recovery of munitions and components for future use.
- (2) *Emergency disposal*—the immediate elimination of munitions or components by concealment, such as burial or submersion. Instruction for

disposal are found in the appropriate technical manuals (app. I).

- (3) *Emergency destruction* — the blasting, mutilating, fragmenting, and burning of munitions and components. Instructions for destruction are found in the appropriate technical manuals (app. I).

b. In emergency denial, the following priorities are observed:

- (1) Nuclear components.
- (2) Associated classified materiel such as firing devices, repair parts, test equipment, and documents.
- (3) Unclassified documents and materiel.

4-12. Timer Option

a. To insure positive control and safety for ADM missions in which a timer option is employed, accurate timer calculations are essential. Moreover, in the event of a canceled or delayed mission, it is important for the protection of recovery or disarming personnel that the time of detonation has been precisely determined and recorded. Timers may be used as either a primary or secondary (backup) means of detonation. When timers are employed, it is *not* possible to state that an ADM will fire at a specific time. There is always a time span or *span of detonation* involved.

b. The *span of detonation* is that total period between the earliest possible time of detonation and the latest possible detonation time. This time span is due to the integral timer error. *Early time* is the earliest possible time that the munition can detonate because of timer error. Conversely, *late time* is the latest

possible time the munition can detonate. *Fire time* is that time when the munition will detonate should the timers function precisely without error. In other words, *fire time* is that time of day resulting from the addition of the time physically set on the timers to the time of day the timers are started. This *fire time* falls between *early time* and *late time*, but is not necessarily the midpoint in the *span of detonation*. *Starting time* is the actual time that the timers are started. *Set time* or *total time* is the time actually set on the timers and encompasses the entire period from starting time to fire time. An illustration of these time factors appears in figure 4-1.

c. There are four basic types of timer calculations that the prefire team may be required to make—

- (1) Given the time and the fire time: find the early, late, starting, and total times.
- (2) Given the early and late times: find the starting, fire, and total times.
- (3) Given the starting and early times: find the late, fire, and total times.
- (4) Given the starting and late times: find the early, fire, and total times.

d. When timers are utilized to backup the remote option, a special problem arises. This problem is to calculate the *total time* physically set on the timers so that they will positively run down and initiate the ADM no earlier than the prescribed *fire time* of the remote option but as close to that time as possible. The calculation for timer option is accomplished by utilizing the *fire time* with the remote option as the earliest possible detonation time.

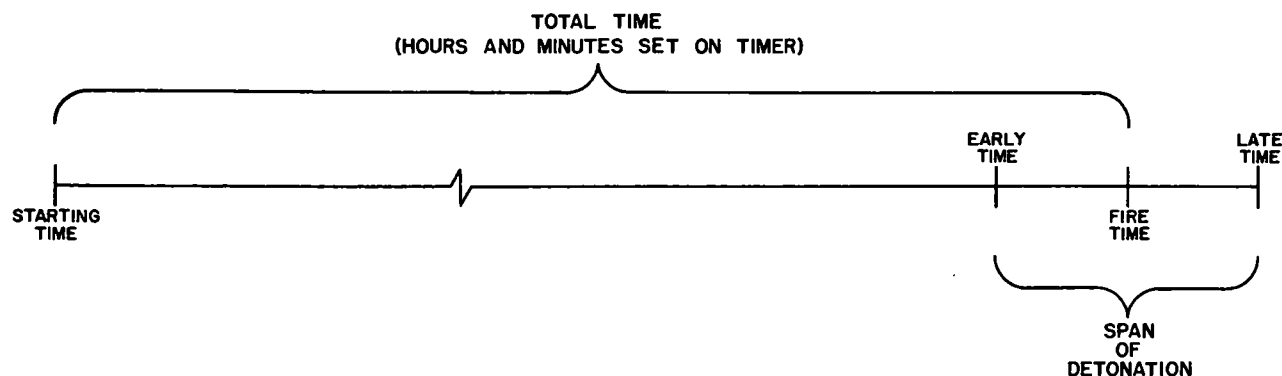


Figure 4-1. Timer calculations.

Section II. ENGINEER ADM TEAMS

4-13. General

To provide ground forces with a capability for atomic demolition munitions employment, engineer ADM teams and platoons have been organized. These ADM units provide technical requisites for the execution of ADM missions; however, additional combat and combat service support must be furnished before mission implementation. Normally, ADM units are assigned or attached to other combat engineer organizations for logistical and administrative support. Upon receipt of an ADM mission and in accordance with the type, magnitude, and number of targets in the employment area, ADM units are usually attached for command and control to the tactical formation charged with the execution of the mission and for the duration of the specific operational phase. ADM units are capable of providing technical advice for ADM employment; technical supervision in the preparation of sites to meet ADM emplacement requirements; performance of all pre-fire checks; and, on order, detonation of the munition. The engineer ADM emplacing element also provides physical security for the munition and associated classified equipment. The safeguarding of ADM defense information is a command responsibility which ultimately

rests with the ADM unit leader. The ADM unit leader must explain the security precautions required in safeguarding ADM defense information to and coordinate security requirements with the supported unit commander. The supported unit must assist in establishing and meeting these security requirements.

4-14. Atomic Demolition Munition Teams

In order to achieve maximum flexibility and to reduce manpower and training requirements, three types of ADM teams are organized (TOE 5-500). Each team is dependent, however, upon the unit to which attached for combat support, combat service support, and tactical and local security.

a. Atomic Demolition Munitions Platoon Headquarters, Separate (TEAM MA).

- (1) This team provides qualified personnel and necessary equipment for the command and control of an ADM platoon composed of from two to six atomic demolition munitions teams (MC). The team may be attached to an engineer combat group or battalion (Army), other U. S. combat units and task forces, or allied mili-

tary organizations. The team consists of a platoon leader, a platoon sergeant, a clerk, a radiotelephone operator, and a light truck driver.

- (2) The platoon leader commands the platoon and is responsible for its training and technical employment. In addition, he serves as a special advisor in ADM operations to the unit to which attached. Upon detachment of subordinate teams for a specific ADM mission and in accordance with the tactical situation and size of the ADM platoon, the platoon leader may assume command of a portion of the platoon placing the remainder of the platoon under the command of the platoon sergeant; or he may conduct liaison between the deployed ADM teams and the supported headquarters coordinating matters of ADM employment and associated matters of communications, supply, and security.
- (3) The platoon headquarters is equipped with a ¼-ton utility truck, a 2½-ton cargo truck, and a radio set, AN/VRC-47, which furnishes a communications link between elements of the platoon and higher headquarters.

b. Atomic Demolitions Munitions Liaison Officer (TEAM MB). This team consists of an ADM liaison officer who acts in the capacity of a special staff officer providing technical knowledge and advice for ADM employment. He may be attached to a US Army unit or allied unit which requires technical assistance in ADM employment. In addition to this staff function, Team MB performs liaison between the headquarters to which attached and other supporting or attached ADM teams. The liaison officer is furnished a ¼-ton utility truck but has no organic communications equipment.

c. Atomic Demolitions Munitions Squad (TEAM MC). This team consists of the team leader and four ADM specialists and is responsible for the assembly, preparation for firing, and detonation on order and, if necessary, the

recovery, disassembly, or destruction of ADM. The ADM team is dependent on the unit to which attached for ADM storage, resupply, additional transport, tactical and local security, site preparation, and similar types of combat and combat service support. The squad may be assigned on the basis of one or more to the engineer combat battalion (Army), other U. S. Army combat units and task forces, allied forces, or to increase the capability of the divisional ADM platoon. When two or more of these teams are formed into a platoon, Team MA provides the necessary command and control. Each Team MC is equipped with a 2½-ton cargo truck and radio sets AN/GRC-125 and AN/PRC-25, for internal and external communications.

4-15. Divisional ADM Platoon

a. The organization of each divisional engineer combat battalion (provided as needed for the divisional airborne engineer battalion) includes an ADM platoon. The organization of this platoon is similar to that prescribed for the ADM teams MA and MC (para 4-14) and includes a platoon headquarters and two ADM squads. Platoon headquarters consists of the platoon leader, platoon sergeant, a radiotelephone operator, a clerk, and a light truck driver. The platoon is fully mobile, and a radio set, AN/VRC-47, is provided for platoon communications. Each ADM squad consists of a squad leader and four ADM specialists, one of whom drives the assigned 2½-ton cargo truck. In addition, each squad is authorized one radio set, AN/GRC-125, and one radio set, AN/PRC-25, for internal and external communications.

b. The responsibilities and operations of the ADM platoon leader are similar to those outlined for the platoon leader of Team MA. In addition, the platoon leader serves as a special advisor for ADM technical employment within the division. The capability of the divisional ADM platoon may be augmented by the attachment of one to four ADM squads (Team MC) under which circumstances the platoon leader assumes command of all attachments.

c. The divisional ADM platoon is dependent

upon the assistance of the parent engineer battalion as well as other division elements for operation effectiveness. Close coordination is maintained with the engineer battalion staff to insure that procedures are established to provide each ADM mission with adequate

and timely support. The ADM platoon leader maintains particularly close liaison with the engineer battalion operations section and may be called upon to assist in the technical preparation of the atomic demolition plan and the unit ADM SOP.

Section III. ENGINEER COMBAT SUPPORT

4-16. General

As previously noted, ADM units do not have the capability of conducting independent operations. Successful ADM employment requires detailed staff planning and coordination. Routinely, ADM units are assigned or attached to engineer combat battalions prior to operational employment, and it is the responsibility of these battalion headquarters to insure that efficient ADM standing operating procedures have been established and engineer personnel are trained to effectively accomplish ADM missions. Engineer battalion commanders and staffs continually supervise and coordinate the activities of assigned or attached ADM units. The success or failure of ADM employment rests to a large extent on the prior training and efficiency of the supporting combat engineer battalion as a whole. All combat engineer commanders must be familiar with the special considerations of ADM operations and emplacement site preparation, and their units must be ready to respond immediately to the requirements of the specific situation.

4-17. Security

Although local security of ADM may often be furnished by nonengineers, it is incumbent on all engineer combat units, platoon and above, to be capable of providing well trained security guards when called upon. Engineers frequently escort ADM from the pickup site to emplacement sites; in other instances, combat engineer units may be designated as demolition guards in which case local security of the ADM mission become a direct engineer responsibility. Moreover, engineer combat

units, based on their close association with ADM, may be called upon to establish basic ADM security procedures for the entire command.

4-18. Construction Support

a. ADM emplacement methods vary from simple surface bursts to deep underground burial. As ADM teams have no organic equipment for preparation of emplacement holes, other engineers are often required to support emplacement operations. For example, many ADM emplacement techniques require tampering with sandbags which are most easily supplied by supporting engineers. Engineers may also construct field fortifications for the protection of ADM command sites or improve access routes to emplacement sites. Moreover, the security of ADM sites may be significantly augmented by the installation of mines, barbed wire, and similar obstacles. Such engineer support is beyond the capabilities of ADM teams and is effected through coordination at battalion and higher unit headquarters.

b. The cratering curves presented in chapter 6 demonstrate the influence of depth of burst on crater dimensions. In ADM operations the possibility of emplacing ADM at depths of burst which enhance crater dimensions is determined by the tactical situation and the availability of time, manpower, and suitable construction equipment. Even though local conditions may preclude emplacement of ADM at optimum depth, considerable increase in crater dimensions is gained by detonating nuclear devices at depths less than optimum.

4-19. Methods of Emplacement

a. Emplacement methods fall under the general categories of hasty and deliberate emplacement. Hasty emplacement, which is discussed solely in this section, refers to those expedient methods of rapidly providing shallow holes for nuclear explosives. Deliberate emplacement, on the other hand, includes those methods which involve the use of tunneling or drilling procedures to provide underground shafts for ADM emplacement.

b. The physical characteristics of ADM and environmental limitations determine to a large extent the possibility of rapid subsurface emplacement. A list of required emplacement diameters for the hypothetical family of ADM as well as their subsurface limitations is presented in table 3-1.

c. In tactical situations where emplacement resources are limited and secrecy is important, engineer handtools are used to bury the ADM as deep as practical. In less restrictive tactical operations, more effective methods of emplacement may be employed using equipment and resources found in engineer units.

d. One method of providing rapid access holes for subsurface ADM emplacement is through the use of shaped-charge demolitions. Test results indicate that shaped-charges produce holes suitable for ADM emplacement (FM 5-25). Since the holes produced by shaped-charges are characteristically tapered, consideration must be given to enlarging the overall diameter. Successive shaped-charges also may be used to increase the depth of the hole.

e. One item of equipment available to U. S. engineer combat units that is capable of boring emplacement holes for ADM is the earth auger. The earth auger and shaped-charge demolitions may be used in combination to increase the depth and diameter of the emplacement hole under suitable tactical and terrain conditions.

4-20. Emplacement Hole Stemming

In order to preclude premature escape (venting) to the atmosphere of the gases produced by an ADM buried below the ground surface, the emplacement hole is stemmed or backfilled with a suitable material after emplacement. Stemming, although always desirable from an effects point of view, plays a less dominant role at optimum and deeper depths of burial. The feasibility of stemming, in relation to its impact on the conduct of the ADM mission, must be weighed against the consequent reduction in efficiency. Nuclear cratering experience to date indicates that a dry, uniformly-graded sand performs most successfully as a stemming material. In replacing backfill, extreme care must be taken to protect ADM from damage.

4-21. Preparation of Command Sites

a. Supporting engineer units are often designated to prepare primary and alternate command sites. Although priority is given to the preparation of the primary command site, alternate sites are normally planned, coordinated, and prepared. Alternate sites insure completion of the mission, provide flexibility, and permit safe firing under variable meteorological conditions.

b. Command sites are far enough from the ADM to insure that the demolition guard and firing party are not subjected to initial nuclear effects greater than that specified by the commander. Locations should also consider anticipated fallout although a change in meteorological conditions may dictate detonation of the ADM from an alternate command site. Intervening terrain features may reduce some of the initial nuclear effects; however, terrain masks should not obscure observation of the emplacement site. If direct observation of the emplacement site is not possible, observation may be maintained by aerial surveillance.



CHAPTER 5

ADM TARGET ANALYSIS

Section I. GENERAL

5-1. Factors Considered in ADM Target Analysis

a. General.

- (1) ADM target analysis is an examination of potential targets and surrounding areas to determine military importance, priority of demolition, and munitions required to obtain a desired level of damage. The purposes of analysis are to compare the respective advantages of conventional and nuclear demolitions in achieving desired target damage, to select the most suitable munition available, to investigate the degree and extent of secondary nuclear effects, and to predict conditions in the target area after detonation.
- (2) Nuclear targets are classified according to size, as follows:
 - (a) *Point targets.* A point target may be either a single element type of target such as a bridge, or it may be an area target whose radius is relatively small in comparison to the radius of damage (about 1 to 5).
 - (b) *Area targets.* Larger targets which occupy a sizeable portion of terrain are termed area targets.
- (3) Predicted results for area targets include the fraction of the target area which is expected to be destroyed and is usually expressed as a percentage. For point targets, damaged chiefly by cratering effects, a brief description of damage is required; *for example*: "center pier of bridge and adjacent spans destroyed."

b. *Assumptions.* Analysis is based on the following assumptions:

- (1) *Reliability.* It is assumed that the ADM will be successfully detonated.
- (2) *Area targets.* ADM are normally employed after detailed ground, air, and map reconnaissance of the target area; however, if detailed information is not available, elements of area targets are assumed to be uniformly distributed.
- (3) *Atmospheric conditions.* The influence of atmospheric conditions on initial nuclear effects is not usually considered by the target analyst.
- (4) *Terrain.* If a nuclear detonation occurs within a narrow defile, initial nuclear effects may be reinforced within the valley and reduced outside of valley because of the shielding afforded by the terrain.
- (5) *Burial.* In many instances, damage is predicated upon adequate ADM burial. In tactical situations, the target analyst must be familiar with the burial capabilities of emplacement units and base his analysis on practical construction limitations.

5-2. Data for ADM Target Analysis

a. Tables in appendix II and FM 101-31-2 present technical data to be used in ADM target analysis. These ADM damage tables provide data for most demolition targets. Troop safety tables and contingent effects tables are also included.

b. *The troop safety tables* simultaneously consider initial nuclear effects and the degree of risk to friendly troops in a particular

condition of vulnerability. The tables give the minimum distances that friendly troops must be separated from ground zero to preclude casualties under various conditions of risk and vulnerability. These minimum safe distances (MSD) are based on surface burst initial effects only and do not take into account residual radiation or radiation history (para 5-7).

c. The *damage tables* consider ADM nuclear effects based on surface and/or subsurface bursts. For each ADM, radii of damage against various target elements are shown.

d. The *contingent effects* tables consider only surface burst effects. For each munition, the tables present the distance to which various effects extend. These effects are—

- (1) Induced radiation.
- (2) Tree blowdown.
- (3) Safety radii for aircraft in flight.
- (4) Fire areas.

e. The tables in FM 101-31-2 have been computed for ADM in the United States stockpile whereas those in appendix II have been computed for a hypothetical family of ADM (table 3-1). The formats, however, are similar. One who understands the techniques of using the unclassified tables can readily make the transition to the classified tables contained in FM 101-31-2.

5-3. Recommendations

a. *General.* One purpose of target analysis is to select the most suitable ADM for destroying the target under consideration. After target analysis has been completed, the following recommendations are presented to the commander:

- (1) Primary and alternate yields with associated munition types.

- (2) Height or depth of burst.
- (3) Location of ground zero.
- (4) Point of detonation, if applicable.
- (5) Time of burst and firing options.
- (6) Estimated results.
- (7) Troop safety distance.

b. *ADM Model and Yield.* The ADM model and yield to be employed is represented as shown in table 3-1. *For example:* BRAVO/1KT/ADM.

c. *Height or Depth of Burst.* Burst option is normally indicated as surface or subsurface and includes the exact height or depth of burst in meters when applicable.

d. *Ground Zero.* Ground zero (GZ) is the point on the earth's surface at which, above which, or below which, the detonation will occur; GZ is generally designated by UTM map coordinates.

e. *Point of Detonation.* In cases where structures are involved, the point of detonation (burst point) is also specified; *for example:* base of center pier.

f. *Time of Burst and Firing Options.* The time of burst and firing options are determined by both tactical and technical considerations, such as the scheme of maneuver and timer error; it is shown as a date-time group.

g. *Troop Safety.* The distance to which the effects for negligible risk to unwarned, exposed personnel extend is portrayed graphically to the commander. If friendly troops are located within this distance, a graphic presentation is provided depicting the resultant risk and/or protection required. (For further discussion of troop safety, see (para 5-7 and ch. 7).

Section II. TECHNIQUES OF ADM TARGET ANALYSIS

5-4. General Procedure for Analyzing Targets

The following general procedural steps are those used by the target analyst. They serve only as a guide. Some steps may be omitted or changed in order to meet the needs of the

experienced target analyst. These procedural steps closely parallel techniques outlined in appendix IV, FM 101-31-1, particularly in those cases where blast damage constitutes the governing ADM effect.

a. *Step 1—Identify Pertinent Information.*

material on the edge of the crater to form a lip.

d. *Optimum Burial* (approximately $49 W^{0.3}$ meters or $160 W^{0.3}$ feet). Optimum depth of burst is that depth of burst at which either the crater radius, depth, or volume is maximized. At this depth of burst all three processes (plastic deformation, spall, and gas acceleration) contribute to crater formation.

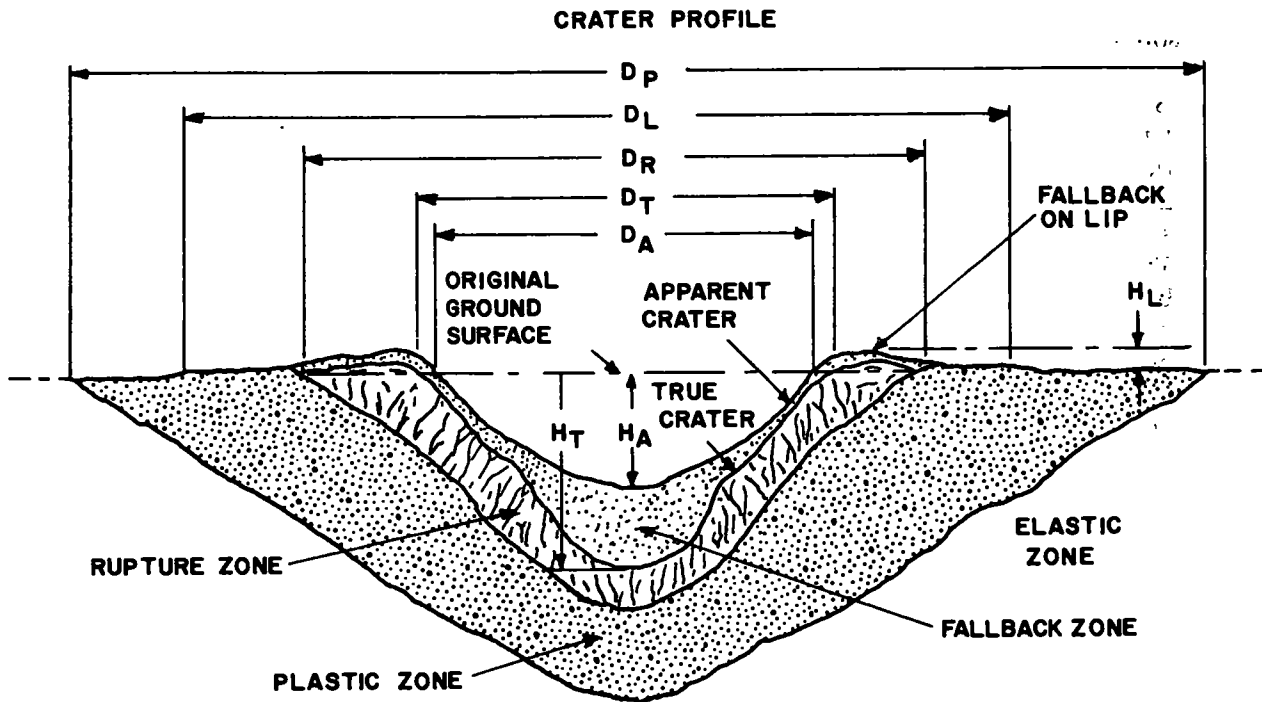
e. *Subsidence*. See paragraph 6-4.

6-6. Scaling of Crater Dimensions

a. To predict cratering dimensions for various yields and depths of burst, it is necessary to apply a basic scaling law to presently available cratering data. An empirical 0.3 power

scaling law has been derived from past cratering tests. Using this scaling law, yields may be correlated to establish the relationship between crater dimensions and depth of burst by normalizing all dimensions to those applicable to a yield of 1 kt. The depth of burst and crater radius resulting from a given yield are normalized by dividing by $W^{0.3}$. The yield (W) is expressed in kilotons. For scaled depths equal to or less than 1.5 meters (5 ft), the radius and depth of crater is scaled as $W^{1/2}$.

b. Figure 6-1 shows specific crater dimensions and the methods by which they may be derived for actual yields and depths of burst once basic data have been determined by scaling. Definitions of zones of disturbance are given in paragraph 2-18.



D_A = DIAMETER OF APPARENT CRATER

H_A = DEPTH OF APPARENT CRATER

D_T = DIAMETER OF TRUE CRATER

H_T = DEPTH OF TRUE CRATER

D_L = DIAMETER OF LIP = $2.0 D_A \pm 25\%$

R_A = RADIUS OF APPARENT CRATER = $\frac{D_A}{2}$

R_C = RADIUS OF CAVITY

$R_C = 45(W)^{1/3}$ FT OR $14(W)^{1/3}$ METERS

H_L = HEIGHT OF LIP = $0.25 H_A \pm 50\%$

D_R = DIAMETER OF RUPTURE ZONE
= $1.5 D_A \pm 25\%$

D_P = DIAMETER OF PLASTIC ZONE
= $3 D_A \pm 50\%$

V_C = VOLUME OF APPARENT CRATER

$$V_C = \frac{\pi}{2} H_A (R_A)^2$$

$$H_T = DOB + R_C$$

Figure 6-1. Crater dimensions.

6-7. Cratering in Various Media

Cratering data for various substances have not been fully developed. Sound engineering judgment and knowledge of the operational area are desirable in estimating specific crater dimensions. In this text, cratering data is pro-

vided for various media as follows:

a. *Dry Soil and Soft Rock.* Figure 6-2 gives the estimated apparent crater dimensions as a function of depth of burst for 1-kt bursts in dry soil or soft rock.

b. *Hard Rock and Concrete.* By using a

multiplication factor of 0.8, the crater curves for dry soil and soft rock (fig. 6-2) may be used.

c. *Wet Soils.*

- (1) *Unconsolidated.* Marine muck typifies such wet, sedimentary material and is composed of soft, very moist silts, clays, and organic deposits. These deposits are usually gray to blue if primarily silt and yellow if primarily clay. Figure 6-3 shows cratering curves for this soil type.
- (2) *Compacted.* Residual clay typifies such material which consists of a

compact, slightly plastic, cohesive clay. It is a residual product which has been developed by rapid rock decomposition inherent to regions of heavy rainfall, warm climate, and rank vegetation. The residual clay curves (fig. 6-4) are used to predict crater dimensions in wet clay. A lower limit water content of 25 percent is used as the classification criterion for wet clay. Dry soil curves (fig. 6-2) are used to predict crater dimensions in soils with a moisture content less than 25 percent.

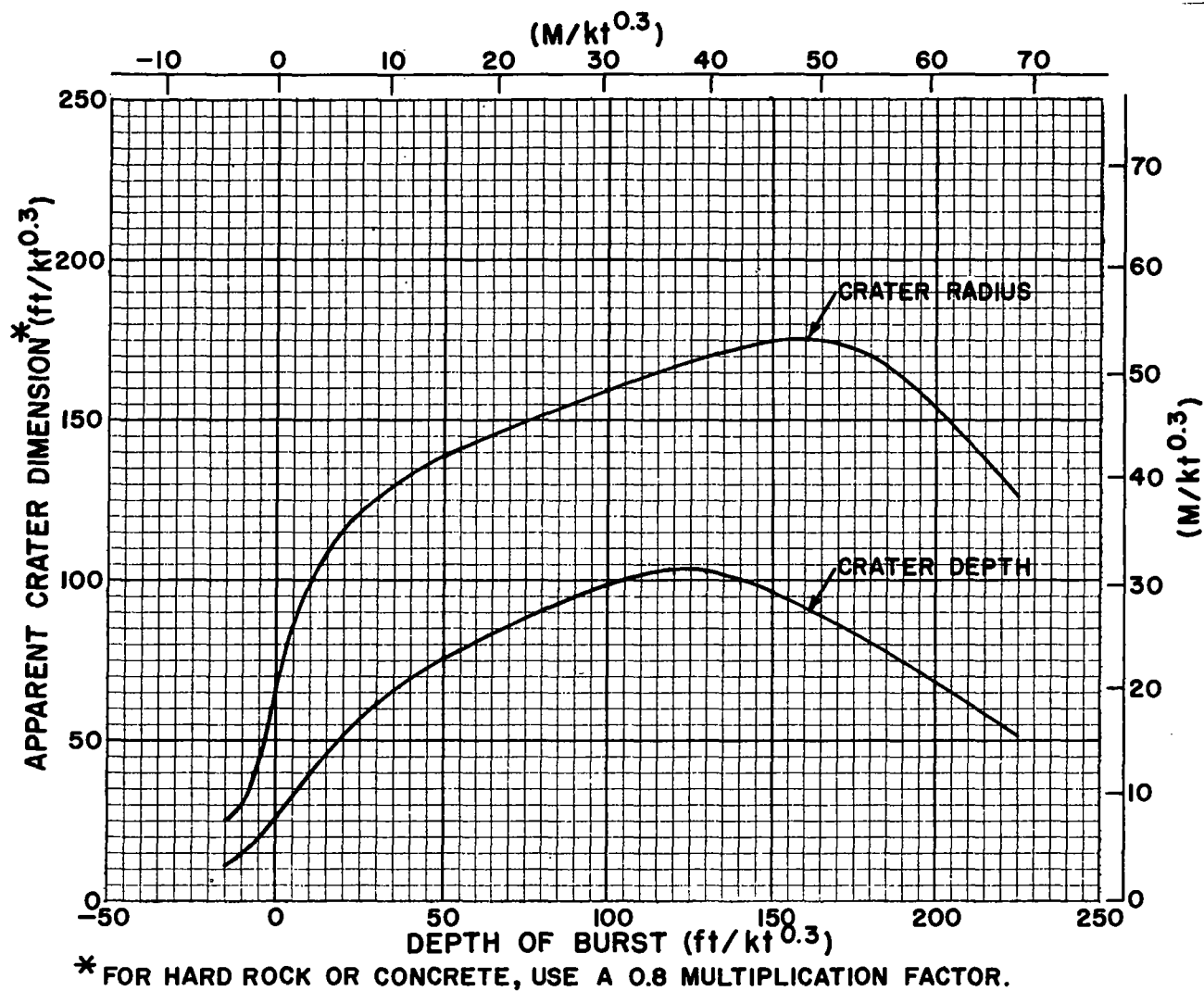


Figure 6-2. Apparent crater dimensions versus depth of burst in dry soil or soft rock (normalized to 1 kt).

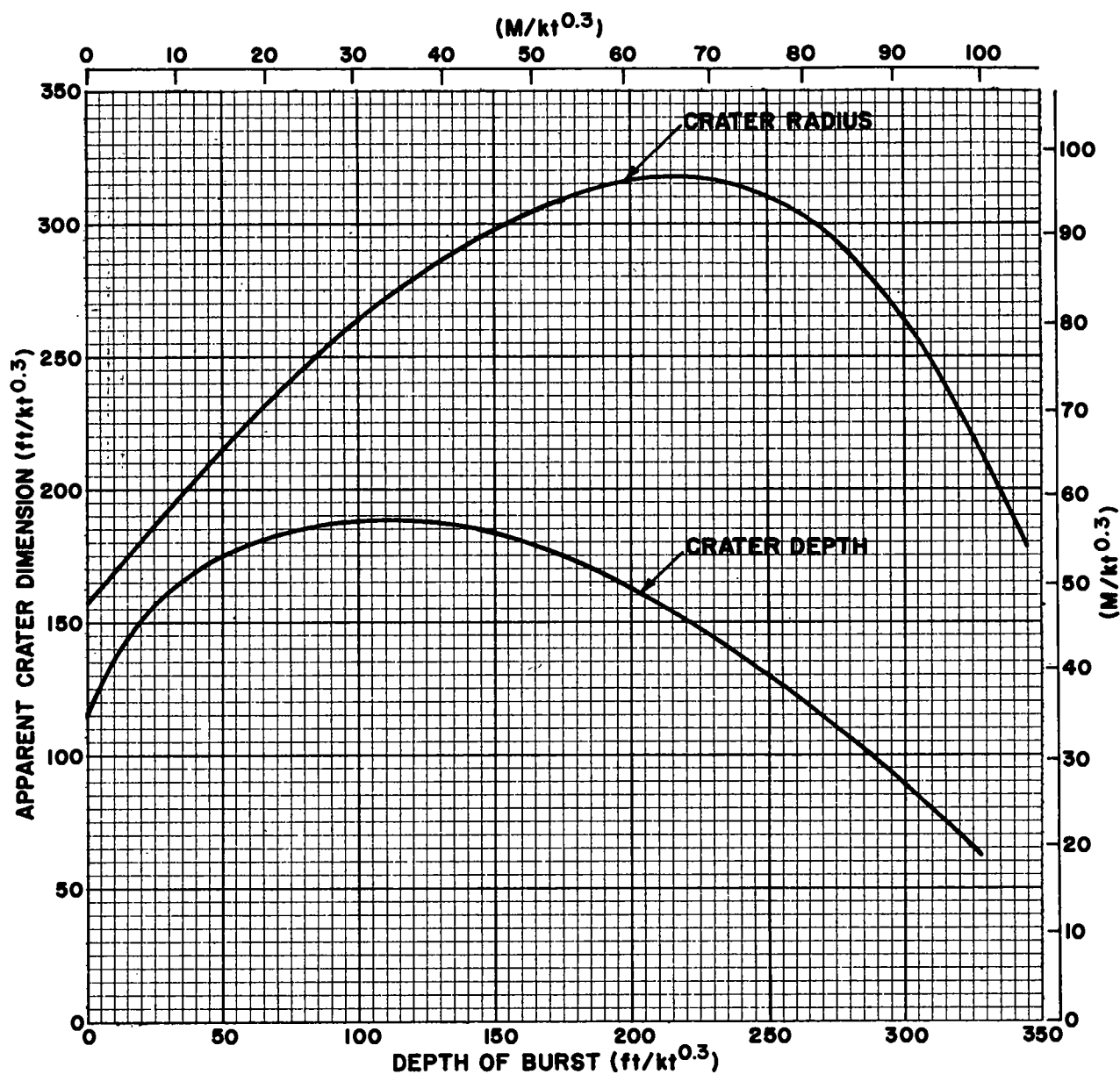


Figure 6-3. Apparent crater dimensions versus depth of burst in marine muck (normalized to 1 kt).

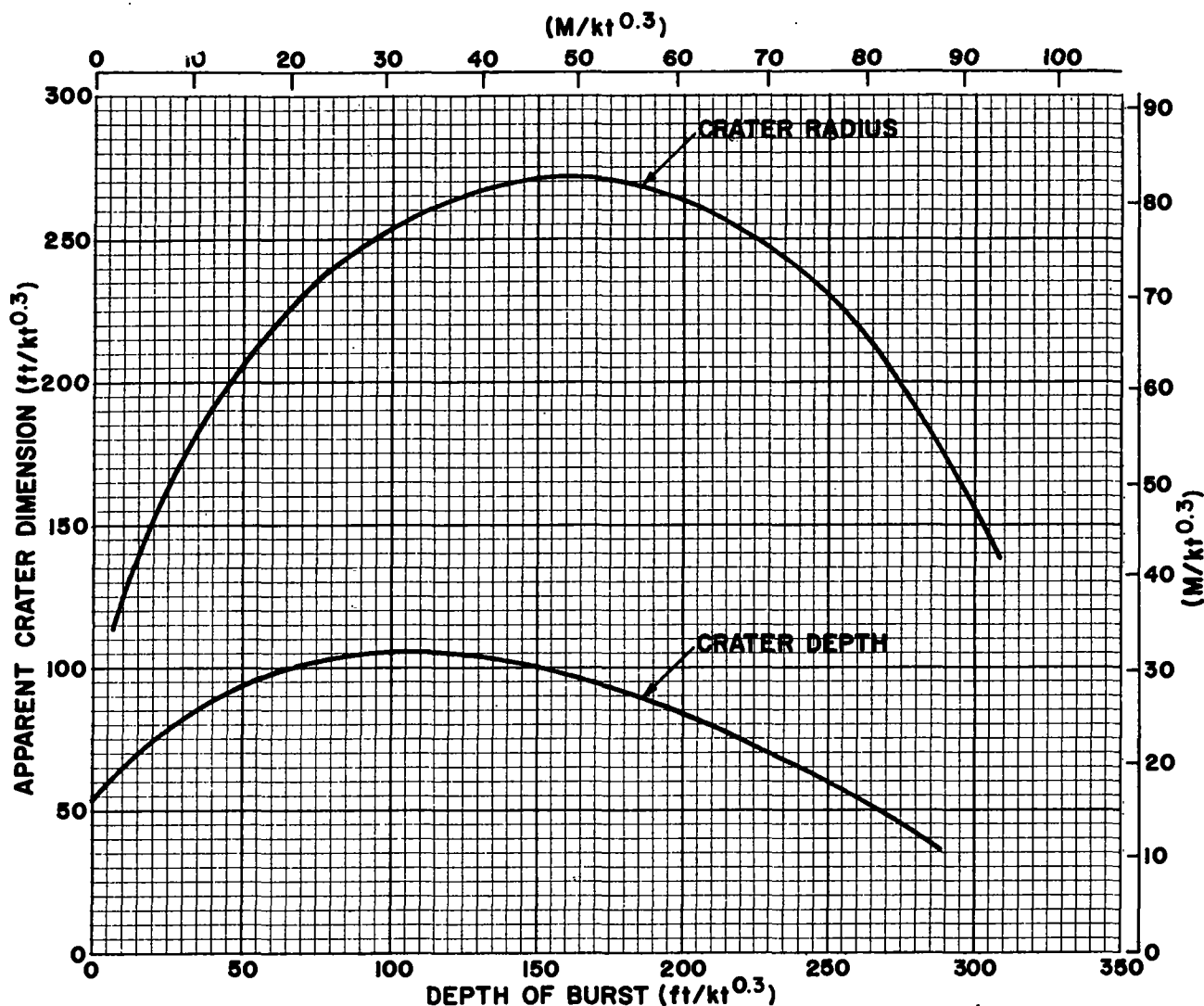


Figure 6-4. Apparent crater dimensions versus depth of burst in residual clay (normalized to 1 kt).

6-8. Use of Cratering Curves and Scaling Laws

In this paragraph, examples are presented which illustrate the use of the cratering curves

and the scaling laws. To use the cratering curves, one must be familiar with the following scaling relationships:

a. *Scaling.* For yields other than 1-kt use—

	Radius of crater	Depth of crater
Surface burst:	$\frac{r_A}{R_A} = \frac{W_1^{1/3}}{W_2^{1/3}} = \frac{dob}{DOB}$	$\frac{h_A}{H_A} = \frac{W_1^{1/3}}{W_2^{1/3}} = \frac{dob}{DOB}$
Subsurface burst:	$\frac{r_A}{R_A} = \frac{W_1^{0.3}}{W_2^{0.3}} = \frac{dob}{DOB}$	$\frac{h_A}{H_A} = \frac{W_1^{0.3}}{W_2^{0.3}} = \frac{dob}{DOB}$

Where r_A = crater radius produced by a yield W_1 at burst depth for 1-kt, dob; and R_A = crater radius produced by a yield W_2 at the actual depth of burst, DOB.

b. Illustrative Example.

Given: A 30-kt burst at a depth of 50 ft in dry soil.

Find: The apparent crater radius.

Solution: The burst depth for 1-kt is—

$$\text{dob} = \frac{50 \times 1}{(30)^{0.3}} = 18 \text{ feet or } 5.5 \text{ meters.}$$

From figure 6-2 the apparent crater radius (and also the true crater radius) for 1-kt is 114 feet.

Answer: Hence the crater radius for 30-kt is—

$$R_A = \frac{114 \times (30)^{0.3}}{1} = 317 \text{ feet or } 97 \text{ meters.}$$

6-9. Apparent Crater Characteristics

a. Shape of the Apparent Crater. The shape of the apparent crater varies significantly with the depth of burst of the ADM. Craters resulting from surface detonations have flat slopes and are relatively shallow in depth while detonations in the vicinity of optimum depth of burst produce craters with relatively steep slopes. Although the shape of the crater varies with depth of burial, the crater cross section remains approximately parabolic.

b. Apparent Crater Lip. The apparent crater lip consists of the material lying above the original preshot ground surface. Formation of the apparent lip results from the upward displacement of the ground surface and the deposit of throwout material around the periphery of the crater. The upthrust portion of the lip is defined as the true crater lip, while the material deposited on top of the true crater lip (ejecta) combine with the true lip to form the apparent crater lip. The characteristics of the apparent crater lip depend on the yield, depth of burial, and the media in which the detonation occurs. Lip height and diameter achieve their greatest dimensions in rock media.

6-10. True Crater Characteristics

a. General. The true crater is defined as the boundary between the fallback material and the underlying material which has been crushed and fractured but has not experienced significant vertical displacement. The characteristics of the true crater are of primary interest to the engineer when considering military applications involving the demolition of hard targets.

b. True Crater Radius. The true crater radius is defined as the radius of the circle that best describes the intersection of the preshot ground surface with the walls of the true crater. For depths of burst up to optimum, the true crater radius and the apparent crater radius are approximately equal.

c. True Crater Depth. The expansion of the high-pressure gases generated by a nuclear explosion in soil or rock produces a cavity surrounding the detonation. The depth of the true crater is equal to the depth of burst of the ADM plus the radius of the cavity created by the detonation. The ultimate cavity size depends on the growth rate of the cavity, the propagation velocity of the stress wave produced by the detonation, the depth of burst, and the yield of the ADM. In the range of yields and depths of burst of interest to the military engineer, the cavity radius is approximately equal to—

$$R_C = 45 W^{1/3} \text{ feet}$$

or

$$14 W^{1/3} \text{ meters}$$

$$R_C = \text{cavity radius}$$

$$W = \text{device yield in kilotons}$$

The true crater depth, therefore, may be determined from the equation—

$$H_T = \text{DOB} + R_C = \text{DOB feet} + 45 W^{1/3} \text{ feet}$$

$$H_T = \text{true crater depth.}$$

$$\text{DOB} = \text{depth of burst.}$$

d. Shape of True Crater.

- (1) The shape of the true crater varies with depth of burial. The true crater profile for depths of burst up to 15 $W^{0.3}$ meters (50 $W^{0.3}$ feet) is parabolic.
- (2) For depths of burst greater than 15

$W^{0.3}$ meters, the outline of the cavity becomes discernible and the sides of the true crater approach a conical configuration.

- (3) The true crater shape of subsidence craters is approximated by a cylinder of radius 10 percent greater than the cavity radius and a depth slightly greater than the depth of burial.

e. True Crater Volume. The volume of the true crater (V_T) can be approximated by adding the volume of the lower hemisphere of the cavity and the frustrum of the cone forming the upper portion of the true crater:

$$V_T = \frac{\pi}{3} DOB (R_T^2 + R_T R_C + R_C^2) + \frac{2\pi}{3} (R_C)^3.$$

f. True Crater Lip. The lip of the true crater is formed from the upward displacement of the ground surface arising from the expansion of the cavity formed by the energy released from the device. The amount of displacement that occurs is dependent upon the properties of the soil media, the ADM yield, and depth of burial.

6-11. Characteristics of Rupture and Plastic Zones

a. Rupture Zone in Rock Media. The rupture zone resulting from a cratering detonation in a rock medium extends beyond the true crater boundaries for varying distances depending upon the crater region involved and the depth of burial. For shallow or optimum depths of burial directly below the ADM

where the confining pressures are high, the rock may be fractured to a distance of 1.5 cavity radii ($1.5 R_C$) from the point of detonation. The sides of the rupture zone in the vicinity of the point of detonation may extend to 3 cavity radii ($3.4 R_C$). Above the point of detonation, the boundary of the rupture zone is nearly parallel to sides of the true crater. For surface and near surface bursts the rupture zone extends approximately 1.5 times the radius of the crater ($1.5 R_A$) from ground zero. Figure 6-5 shows the probable shape and extent of the rupture zone in rock.

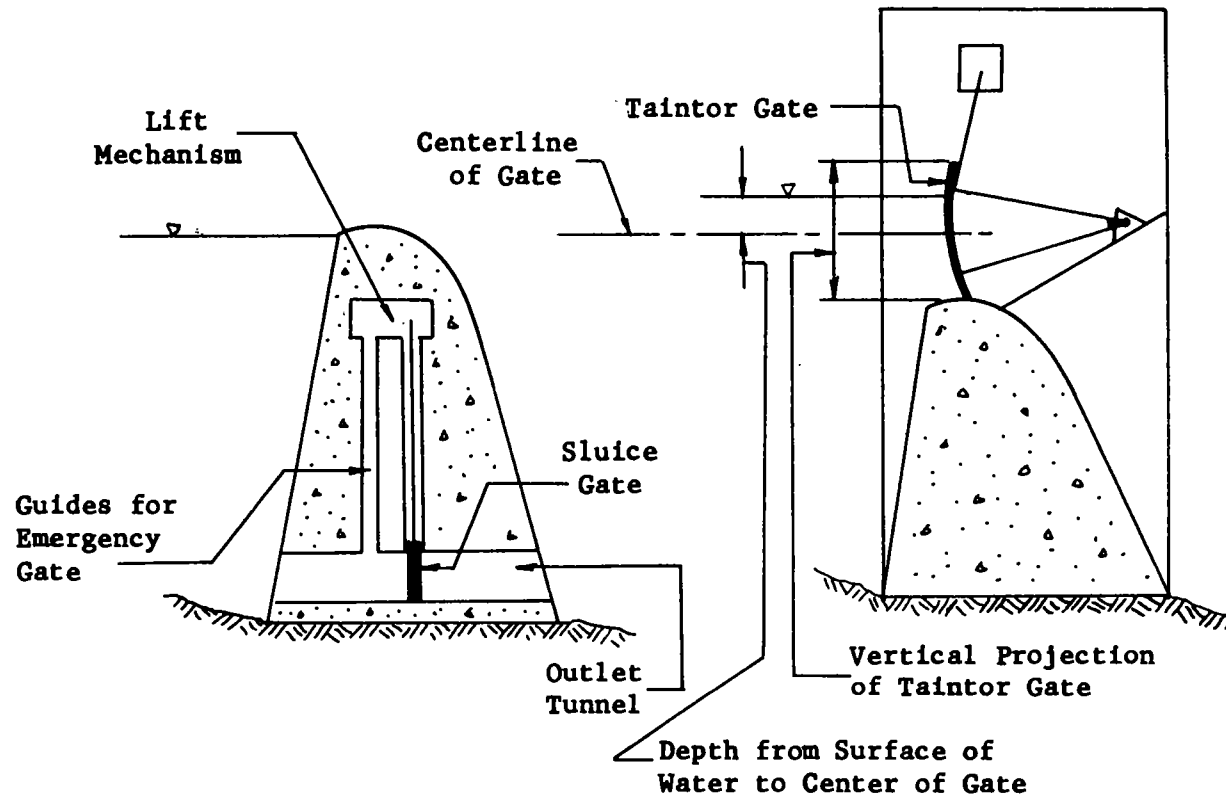
b. Plastic Zone in Rock Media. Since the fracture and yield stresses in most rock media are almost equal, the plastic zone, if it exists at all, extends only slightly beyond the rupture zone. The boundaries of the plastic zone are roughly parallel to the rupture zone boundaries. In rock media, the plastic zone has essentially the same strength and permeability as the undisturbed rock.

c. Characteristics of Rupture and Plastic Zones in Soil. The extent of the disturbed region resulting from an explosion in soil media is determined primarily by the shearing stresses produced by the detonation. When a soil medium is subjected to shearing stresses greater than the shearing strength of the soil, plastic deformation occurs. Since the material in both the rupture and plastic zones of a soil medium is subjected to permanent deformation as a result of shear failure, it is most difficult to differentiate between the rupture and plastic zones.

large enough and close enough to blow out the gates also causes cracking and probable failure of the dam itself.

c. Depending upon the design of the dam, the spillway gates may extend along the entire dam s outside the cratering radius, can the length. Spillway gates are usually the most vulnerable part of the dam. Although accessible taintor gates (a common spillway gate) are usually more vulnerable to conven-

tional demolition charges applied to the lower radial strut, they may be blown out by the hydrostatic shock wave generated by nuclear detonation underwater upstream from the reservoir. This may be achieved without severe damage to the dam itself. The distance, of course, depends upon the size of the munition and the installation and strength of the gates. Other types of spillway gates may be expected to react similarly.



SLUICE GATE

Figure 6-48. Cross sections of sluice and spillway gates.

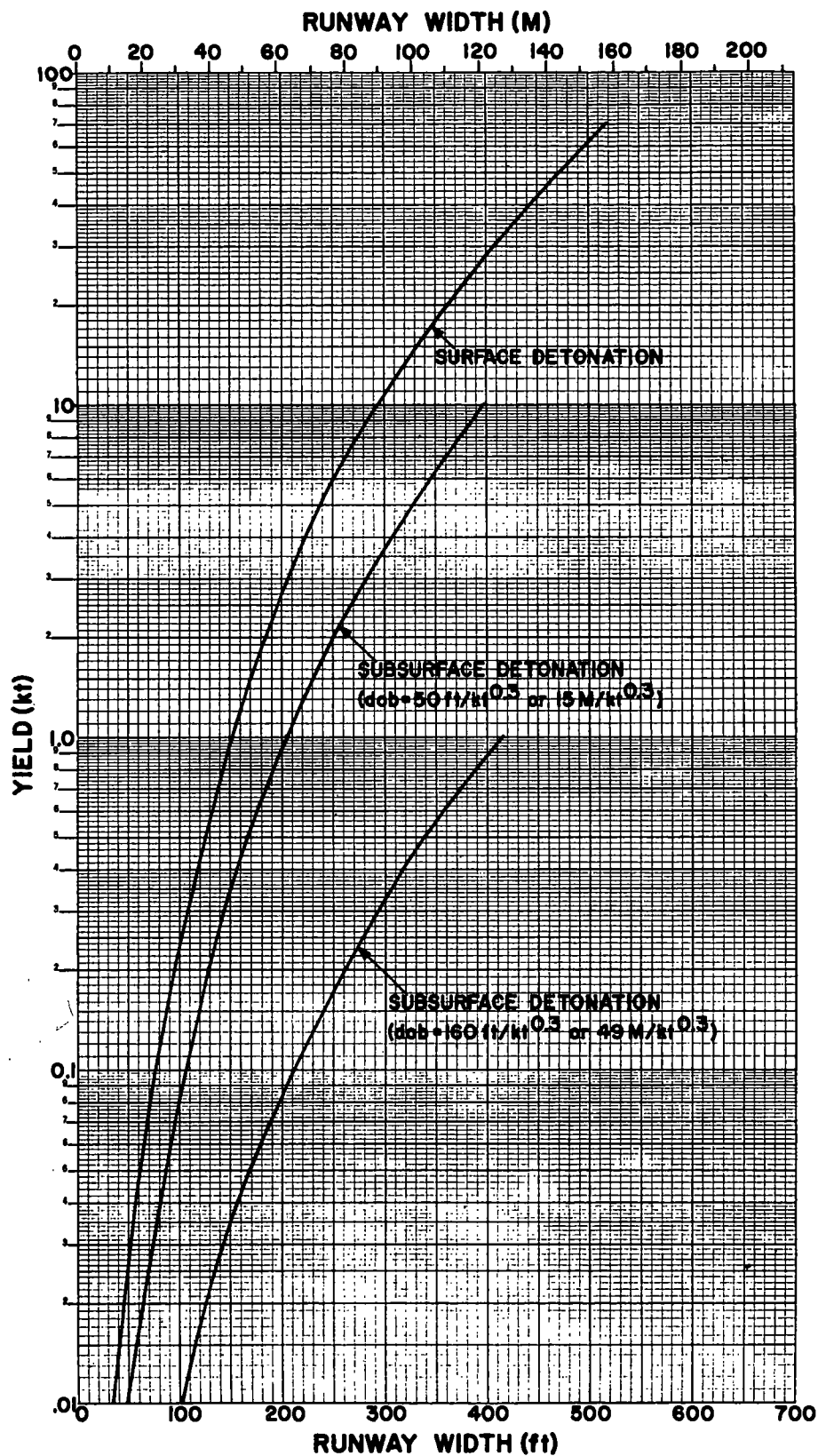


Figure 6-75. Yield selection criteria for runway demolition.

c. *Subsurface Emplacement.* For subsurface detonations other than near surface bursts, the concrete runway slab has little effect on the dimensions of the crater produced. Even for shallow depths of burst the concrete slab is thin compared to the depth of burial, and the higher strength and density of the concrete does not greatly influence the size of the crater. The governing medium for subsurface detonations, therefore, is the subgrade material which is assumed to have cratering characteristics similar to desert alluvium. Figure 6-75 gives curves, based on cratering experience in dry soil, for determining runway cratering yield requirements for a scaled depth of $50 \text{ ft/kt}^{0.3}$ ($15 \text{ m/kt}^{0.3}$) and $160 \text{ ft/kt}^{0.3}$ ($49 \text{ m/kt}^{0.3}$). Should these depths exceed emplacement capability the procedures outlined in paragraph 6-8 are followed based on the maximum depth attainable.

d. *Illustrative Example.* The following ex-

ample illustrates the recommended procedure for determining the yield requirements and emplacement locations for demolition of runways.

Given: Figure 6-76 shows the layout of an airfield designed to handle heavy jet bombers. A demolition mission is planned with the objective of denying the use of the runway facilities for jet bombers and fighters. The maximum continuous length of undamaged runway which can remain after the demolition mission and accomplish the objective is 4900 feet (1500 meters).

Find: The ADM yields and emplacement positions required for the demolition mission for surface detonations; detonations at a scaled depth of $50 \text{ ft/kt}^{0.3}$; and detonations at a scaled depth of $160 \text{ ft/kt}^{0.3}$. Assume a minimum separation distance for multiple ADM surface detonations of 3300 feet (1000 meters).

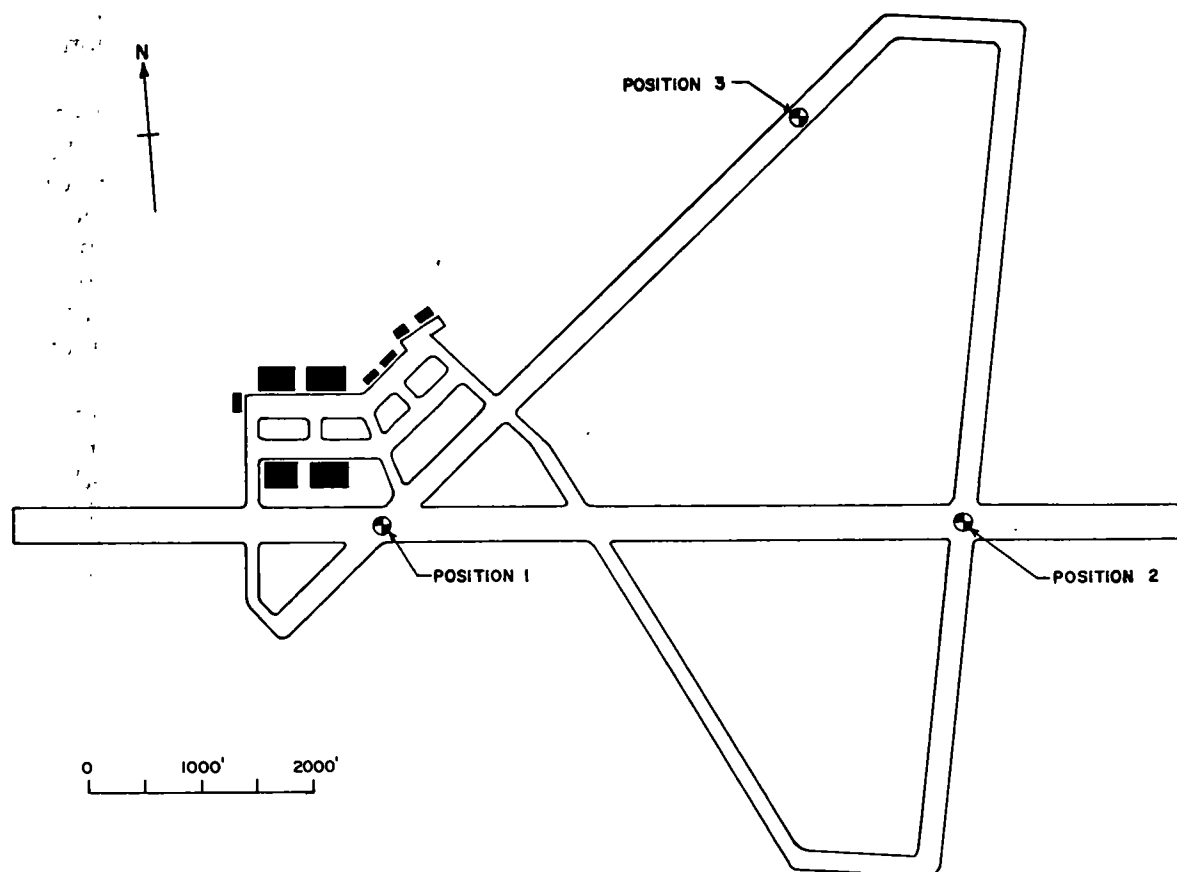


Figure 6-76. Airfield layout and ADM emplacement positions for illustrative example.

Solution:

- (1) *Emplacement positions.* The location of the ADM on the runway complex is the same for surface and sub-surface detonation. Analysis of the runway layout indicates that a minimum of three ADM (identified as position 1, 2, and 3 in fig. 6-76) is required in order to deny all runways. Detonation of ADM at positions 1 and 2 reduces the undamaged length of the main east-west runway and north-south runway within the presented limits. A detonation at posi-

tion 3, together with the detonation at position 1, reduces the undamaged length of the SW-NE runway to less than 4900 feet.

- (2) *Yield selections—surface detonations.*
 - (a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for surface burst and runway width of 300 feet, yield required is 10.4 kt.

Answer: Use ECHO/10 kt (table 3-1).

- (b) Position 3: Width of SW-NE run-

way = 200 feet. Referring to figure 6-75 for surface burst and runway width of 200 feet, yield required is 2.7 kt.

Answer: Use DELTA/5KT (table 3-1).

(3) *Yield selection — subsurface detonations (scaled depth of 50 ft/kt^{0.3}).*

- (a) Positions 1 and 2: Width of E-W runway = 300 feet (governing width). Referring to figure 6-75 for scaled depth of 50 ft/kt^{0.3} and runway width of 300 feet, yield required is 3.7 kt.

Answer: Use DELTA/5 kt (table 3-1).

- (b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for scaled depth of 50 ft/kt^{0.3} and runway width of 200 feet, yield required is 0.93 kt.

Answer: Use BRAVO/1 kt (table 3-1).

(4) *Yield selection — subsurface detonations (scaled depth of 160 ft/kt^{0.3}).*

- (a) Positions 1 and 2: Width of E-W runways = 300 feet (governing width). Referring to figure 6-75 for scaled depth of 160 ft/kt^{0.3} and runway width of 300 feet, yield required is 0.33 kt.

Answer: Use ALFA/0.5 kt (table 3-1).

- (b) Position 3: Width of SW-NE runway = 200 feet. Referring to figure 6-75 for scaled depth of 160 ft/kt^{0.3} and runway width of 200 feet, yield required is 0.08 kt.

Answer: Use VICTOR/0.1 kt (table 3-1)

(5) *Summary of yield requirements.*

Position No.	Yield Required		
	Surface	Subsurface (50 ft/kt ^{0.3})	Subsurface (160 ft/kt ^{0.3})
1	10 kt	5 kt	0.5 kt
2	10 kt	5 kt	0.5 kt
3	5 kt	1 kt	0.1 kt

The yield requirements listed above are indicative of the advantage to be gained by subsurface emplacement as compared to surface bursts. Furthermore, the radioactivity released from the subsurface detonation is less than from the surface bursts because the total yield requirements for subsurface detonations are significantly smaller than for surface bursts; and the fraction of radioactivity released to the atmosphere is less for the subsurface detonation than for the surface detonation of any given yield.

Section VIII. MISCELLANEOUS ADM TARGETS

6-54. General

Special target analysis techniques for ADM in which cratering for point targets is the governing effect were discussed in paragraph 6-3 through 6-53. It should not be forgotten, however, that ADM have a mass destruction capability and are suitable for employment on targets susceptible to nuclear effects other than cratering. Moreover, target analysis is not complete until the target area is analyzed for contingent effects. Either the visual or numerical method of target analysis is applicable for analyzing area targets utilizing the damage tables and contingent effects tables in appendix II or FM 101-31-2. This section discusses in general terms other tar-

gets appropriate for ADM attack in which the crater effect may not be governing.

6-55. Railroad Marshaling Yards

A railway marshaling yard is an area target susceptible to blast and cratering effects. Repair facilities, roundhouses, engine sheds, and rolling stock are primarily damaged by blast while turntables and switching facilities are most effectively damaged by cratering. In cratering a railroad yard, the depth of crater is less important than width since any significant disruption of the rails requires major rehabilitation. Blast damage criteria for various yields are shown in the damage tables; cratering data may be obtained from paragraph 6-3 through 6-14.

APPENDIX I**REFERENCES**

A1-1. Army Regulations

AR 55-203	Movement of Nuclear Weapons Components and Nuclear Weapons Material
AR 95-55	Nuclear Weapon Jettison
AR 190-60	Physical Security Standards for Nuclear Weapons
AR 380-5	Safeguarding Defense Information
AR 380-20	Restricted Areas
AR 380-25	Visitors
AR 380-55	Safeguarding Defense Information in Movement of Persons and Things
AR 380-150	Security of Restricted Data
AR 380-157	Policy and Procedure for Regulating Access to Critical Atomic Weapons Stockpile and Production Information
AR 385-25	Studies and Reviews, Nuclear Weapon System Operational Surety Program
AR 385-30	Safety Color Code Markings and Signs
AR 385-40	Accident Reporting and Records
AR 385-65	Identification of Inert Ammunition and Ammunition Components
AR 580-15	Security Requirements for Nuclear Weapons
AR 604-5	Clearance of Personnel for Access to Classified Defense Information and Materiel
AR 611-15	Selection and Retention Criteria for Personnel in Nuclear Weapons Positions
AR 611-103	Officer Qualifications and Classification
AR 611-201	Manual of Enlisted Military Occupational Specialties
AR 600-200	U.S. Army Replacement System Criteria for Assignment of Enlisted Personnel to Certain Organizations
AR 700-945	Safeguarding Weapons and Ammunition

A1-2. Field Manuals

FM 3-8	Chemical Corps Reference Handbook
FM 3-10	Chemical and Biological Weapons Employment
FM 3-10A	Chemical and Biological Weapons Employment (U)
FM 3-12	Operational Aspects of Radiological Defense
FM 3-15	Nuclear Accident Contamination Control
FM 5-1	Engineer Troop Organization and Operations
FM 5-15	Field Fortifications
FM 5-25	Explosives and Demolitions
FM 5-29	Passage of Mass Obstacles
FM 5-31	Booby Traps
FM 5-34	Engineer Field Data
FM 5-35	Engineers' Reference and Logistical Data
FM 5-36	Route Reconnaissance and Classification
FM 6-20-1	Field Artillery Tactics
FM 6-20-2	Field Artillery Techniques
FM 9-6	Ammunition Service in the Theater of Operations
FM 19-3	Military Police Support in the Communications Zone
FM 19-25	Military Police Traffic Control
FM 19-30	Physical Security
FM 20-32	Land Mine Warfare
FM 21-30	Military Symbols
FM 21-40	Small Unit Procedures in Chemical, Biological, and Radiological (CBR) Operations
FM 24-18	Field Radio Techniques
FM 24-20	Field Wire and Field Cable Techniques
FM 30-5	Combat Intelligence
FM 30-10	Terrain Intelligence
FM 31-10	Barriers and Denial Operations
FM 61-100	The Division
FM 100-5	Field Service Regulations — Operations
FM 101-5	Staff Officers' Field Manual; Staff Organization and Procedure
FM 101-31-1	Staff Officers' Field Manual; Nuclear Weapons Employment
FM 101-31-2	Staff Officers' Field Manual; Nuclear Weapons Employment
FM 101-31-3	Staff Officers' Field Manual; Nuclear Weapons Employment

A1-3. Technical Manuals

TM 3-210	Fallout Prediction
TM 5-545	Geology and its Military Applications
TM 9-1100-205-12	Operator and Organizational Maintenance Manual: Atomic demolition Charge XM129, XM129E1, XM159, XM159E1, and Training Atomic Demolition Charge XM130 and XM130E1
TM 9-11000-205-20P	Organizational Maintenance Repair Parts and Special Tools List
TM 9-1100-225-12	Operator and Organizational Maintenance Manual (prefire procedures for employment): Atomic demolition charge XM55 and coder-transmitters XM3 and XM4
TM 9-1100 225-20P	Organizational Maintenance Repair Parts and Special Tools List: Charge, atomic demolition: XM55 and coder-transmitters: XM3 and XM4
TM 9-1100-226-12	Operator and Organizational Maintenance Manual: (prefire procedures for employment): Atomic demolition charge XM127 and XM127E1, XM160 and XM160E1, XM166, XM167, XM172, XM173, XM174, and coder-transmitters XM3 and XM4
TM 9-1100-226-20P	Organizational Maintenance Repair Parts and Special Tools List (illustrated parts breakdown) for charge, atomic demolition: XM127 and XM160, and coder-transmitters XM3 and XM4
TM-10-500-4	Rigging Atomic Demolition Charges
TM 23-200	Capabilities of Nuclear Weapons
TM 38-750	Army Equipment Record Procedures
TM 39-0-1	Numerical Index to Joint Atomic Weapons Publications

A1-4. Other DA Publications

TC 3-15	Prediction of Fallout from an Atomic Demolition Munition
DA Pam 39-3	Nuclear Weapons
ASubjScd 5-18	Atomic Demolition Munitions
DA Form 2706	Assignment Certificates
TB IG-5	Inspector General Technical Proficiency Inspection

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A6-3. Area Targets (Visual Method)

a. General. The visual method of analysis consists of a visualization of the fraction of the target covered by the radius of damage using ground zero as the reference point. In order to facilitate this visualization, a transparent circular map scale inscribed with a series of concentric circles and arcs at 100m or 200m-intervals is used (app. V, FM 101-31-1).

b. Yield Determination Procedure.

- (1) Draws a scaled representation of the target.
- (2) With a circular map scale or a comparable substitute, and using ground zero as a reference point, estimate visually the radius of damage required to achieve the coverage (f) desired.
- (3) Select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Illustrative Example.

Given: An engineer equipment park measures 100 meters long and 30 meters wide. The commander desires at least moderate damage to 50 percent of the target area. The situation requires the ADM to be emplaced at the entrance to the equipment park which is situated midway along the short axis.

Find: The minimum ADM yield required to meet the commander's guidance.

Solution:

- (1) The engineer equipment park is drawn to scale.
- (2) With the circular map scale, the required R_D is found to be slightly greater than 50 meters for at least 50 percent coverage.
- (3) From appendix II, the R_D for moderate damage to earthmoving and truck-mounted engineer equipment is found to be 70 meters for the minimum available yield.

Answer: Hence, the SIERRA/.01 kt/ADM is selected.

A6-4. Area Targets (Numerical Method)

a. General. The numerical method of analysis may be used with either circular or approximately circular targets. Ground zero may be at or displaced some distance (d) from target center. The numerical method requires the use of the ADM fractional coverage nomograph, figure VI-2, which has been devised to replace the graphics required by the visual method.

b. Yield Determination Procedure (GZ at Target Center).

- (1) Determine the radius of target (R_T).
- (2) Establish the R_D/R_T ratio required to achieve the fractional coverage (f) desired. This is read directly from the ADM fractional coverage nomograph (fig. VI-2) at the point where the fractional coverage curve of interest intercepts the R_D/R_T index.
- (3) Calculate the radius of damage required; $R_D = R_T$ (value of ratio).
- (4) From the appropriate damage table, select the minimum yield which provides a radius of damage equal to or greater than the R_D required.

c. Yield Determination Procedure (Displaced GZ). Except for entering the fractional coverage nomograph with the d/R_T ratio, the procedure follows that outlined in b above.

d. Illustrative Example (GZ at Target Center).

Given: Moderate damage to 40 percent of the rolling stock located in a railway marshalling yard is desired. The diameter of the target is 240 meters.

Find: The minimum ADM yield required to meet the above requirements.

Solution:

- (1) $R_T = 240/2 = 120$ meters.
- (2) Figure VI-2; for $f = .40$, $R_D / R_T = 0.65$.
- (3) $R_D = 0.65 (R_T) = 0.65 (120) = 78$ meters.
- (4) Appendix II; TANGO/.03 kt/ADM, $R_D = 80$ meters.

Answer: TANGO/.03 kt/ADM.

e. Illustrative Example (Displaced GZ).

Given: In the above problem, limiting requirements have caused ground zero to be displaced 100 meters from target center.

Find: The minimum ADM yield required to meet the 40 percent coverage requirements as stated previously.

Solution:

- (1) $R_T = 120$ meters, $d = 100$ meters.
- (2) Enter figure VI-2 with $d/R_T = 100/120 = 0.83$. For $f = 0.40$, $R_D/R_T = 0.90$.
- (3) $R_D = R_T (.90) = 120 (.90) = 108$ meters.
- (4) Appendix II; UNIFORM/.05 kt/ADM, $R_D = 110$ meters.

Answer: UNIFORM/.05 kt/ADM.

APPENDIX VIII

**FRIENDLY NUCLEAR STRIKE WARNING TO ARMED FORCES
OPERATING ON LAND (STANAG 2104)**

STANAG No. 2104

31 March/mars 1965

**NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE L'ATLANTIQUE NORD****MILITARY AGENCY FOR STANDARDIZATION
BUREAU MILITAIRE DE STANDARDISATION****STANDARDIZATION AGREEMENT
ACCORD DE STANDARDISATION**

SUBJECT

OBJET

**FRIENDLY NUCLEAR STRIKE WARNING TO
ARMED FORCES OPERATING ON LAND****AVIS D'ATTAQUE NUCLEAIRE AMIE DES-
TINE AUX FORCES ARMEES EMPLOYEES
A TERRE**

STANAG 2104

**DETAILS OF AGREEMENT (DofA)
FRIENDLY NUCLEAR STRIKE WARNING TO ARMED
FORCES OPERATING ON LAND****AGREEMENT**

1. It is agreed that the NATO Armed Forces will adopt the following system of friendly nuclear strike warnings for use at corps level and below. This applies to surface-to-surface and air-to-surface strikes in support of ground forces, and to emplaced atomic demolition munitions (ADMs).

GENERAL

2. The requirement for a standard warning message and delineation of notification channels is essential to ensure that timely warning of friendly nuclear strikes is provided so that Armed Forces personnel may take individual measures to protect themselves.

3. For the purpose of the STRIKWARN message, azimuth is the horizontal angle from grid north to a certain point expressed in degrees or mils.

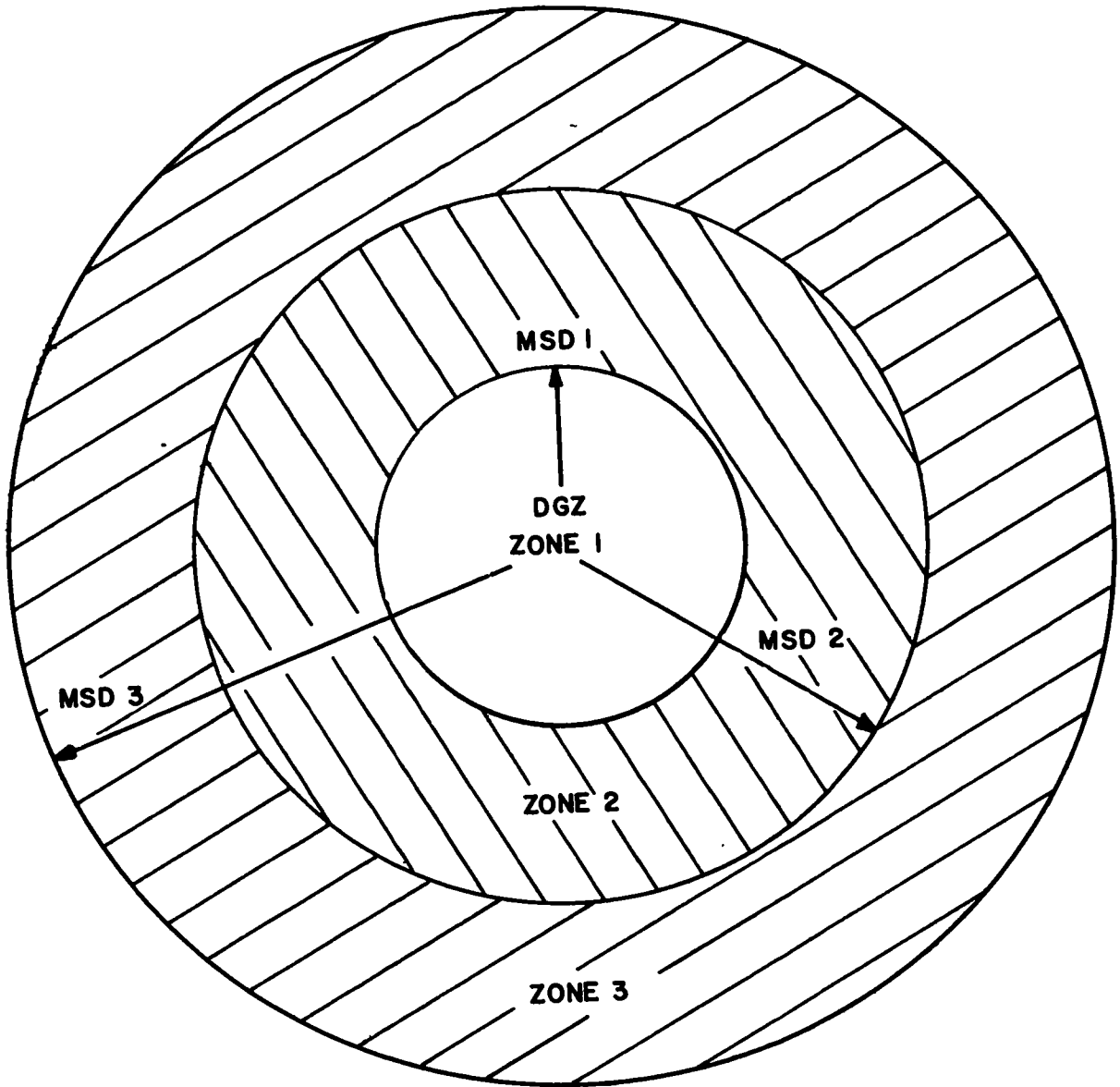
WARNING RESPONSIBILITIES

4. a. Responsibility for issuing the warning rests with the Commander requesting the nuclear strike.

- b. Commanders authorized to release nuclear strikes will ensure that strikes affecting the safety of adjacent or other commands are coordinated with those commands in sufficient time to permit dissemination of warnings to Armed Forces personnel and the taking of protective measures. Conflicts must be submitted to the next higher Commander for decision.

**DETERMINATION OF HEADQUARTERS, FORMATIONS/UNITS
TO BE WARNED**

- 5. a. The Commander responsible for issuing the warning should inform:
 - (1) Subordinate Headquarters whose units are likely to be affected by the strike.
 - (2) Adjacent Headquarters whose units are likely to be affected by the strike.
 - (3) Own next higher Headquarters, when units not under the command of the releasing Commander are likely to be affected by the strike.
- b. Each Headquarters receiving a warning of nuclear attack will warn subordinate elements of the safety measures they should take, in the light of their proximity to the Desired Ground Zero (DGZ).
- c. Each unit concerned, down to the lowest level, will be warned by its next higher level of the safety measures it should take.



6. Figure VIII-1. Zones of warning and protection requirements for friendly nuclear strikes.

NOTES:

1. MSD means Minimum Safe Distance.
2. The MSD is equal to a radius of safety (Rs) for the yield, plus a buffer distance (d_b) related to the dispersion normal to the weapon system used and the orientation of friendly forces in relation to the line of fire. When surface bursts are used, the fallout hazard will be considered and appropriate buffer distances included.

Radius	Corresponding to—	Zone	Requirements
DGZ			
		1	Evacuation of all Armed Forces personnel. (See note 2.)
MSD 1	Limit of negligible risk* to warned and protected Armed Forces personnel. (See note 3.)		
		2	Maximum protection. (See note 4.)
MSD 2	Limit of negligible risk* to warned and exposed Armed Forces personnel.		
		3	Minimum protection. (See note 5.)
MSD 3	Limit of negligible risk* to unwarned and exposed Armed Forces personnel.		
More than MSD 3	-----	----	No protective measure except against dazzle.

NOTES

1. Commanders will be guided by safety criteria as stated in FM 101-31-1, Staff Officers Field Manual, Nuclear Weapons Employment (or appropriate national manuals with the same criteria.)
2. If evacuation is not possible or if a Commander elects a higher degree of risk, maximum protective measures will be required.
3. Negligible risks should not normally be exceeded unless significant advantages will be gained.
4. Maximum protection denotes that Armed Forces personnel are in "buttoned-up" tanks or crouched in foxholes with improvised overhead shielding.
5. Minimum protection denotes that Armed Forces personnel are prone on open ground with all skin areas covered and with an overall thermal protection at least equal to that provided by a two-layer uniform.

WARNING MESSAGES

7. Warning messages will include the following information (See STANAG 2103):

STRIKWARN

ALPHA: Code word indicating nuclear strike (target number)

DELTA: DATE/time group for time of burst in ZULU time.
The time after which the strike will be cancelled (ZULU time).

FOXTROT: DGZ (UTM grid co-ordinates).

HOTEL: Indicate air or surface bursts.

* (as defined in STANAG 2083).

INDIA: For all bursts:

MSD 1 in hundreds of meters, four (4) digits
MSD 2 in hundreds of meters, four (4) digits
MSD 3 in hundreds of meters, four (4) digits

Distance to which Armed Forces personnel must shield their eyes from dazzle—in hundreds of meters, four (4) digits.

YANKEE: For all bursts when there is less than a 99% assurance of no militarily significant fallout.

Azimuth of left then right radial lines (degrees or mils—state which) four (4) digits each.

ZULU: For all bursts when there is less than a 99% assurance of no militarily significant fallout.

Effective wind speed in kilometers per hour, three (3) digits.

Downwind distance of Zone 1 (km), three (3) digits.
Cloud radius (km), two (2) digits.

EXAMPLE MESSAGES

1. **FOR AIR BURSTS WITH 99% ASSURANCE OF NO MILITARILY SIGNIFICANT FALLOUT**

STRIKWARN. ALPHA TUBE SIX. DELTA PO WM OT AR/AS
DG WY OF.

FOXTROT YM AB IM SK. HOTEL AIR. INDIA 0022 0031 0045 0140.

2. **FOR ALL BURSTS WITH LESS THAN 99% ASSURANCE OF NO MILITARILY SIGNIFICANT FALLOUT**

STRIKEWARN. ALPHA TUBE SIX. DELTA PQ WM OT AR/AS
DG WY OF.

FOXTROT YM AB IM SK. HOTEL SURFACE. INDIA 0022 0031
0045 0140.

YANKEE 0215 0255 DEGREES. ZULU 025 080 18.

IMPENDING STRIKE WARNING

8. Warning of impending strikes will be initiated no earlier than is necessary to complete warning of Armed Forces personnel. Any available means of communications—land lines if possible—will be utilized to ensure that all Armed Forces personnel requiring warning are notified.

ACTION ON CANCELLED STRIKES

9. When nuclear strikes are cancelled, units previously warned will be notified in the clear by the most expeditious means in the following format:
 - a. Code Word (Target Number)
 - b. CANCELLED

USE OF CODES

10. Items DELTA and FOXTROT above will not be sent in clear unless the time of initiating the warning message is such that no loss of security is involved.
11. Only coding systems which meet NATO security criteria will be used.

OTHER WARNINGS

12. It is recognized that it is impractical to obtain warnings of surface-to-air (for instance, air defense) nuclear bursts which may occur at low altitudes, and to disseminate such warnings to Armed Forces personnel.
13. Similarly, it may be impractical to provide warning to the Naval and Air forces concerned of intended surface-to-surface strikes delivered by weapons within the corps, especially for fleeting targets or when reaction times are short. Nevertheless, it is the responsibility of Army agencies to provide warning to Naval and Air Forces concerned whenever possible.

IMPLEMENTATION OF THE AGREEMENT

14. This STANAG will be considered to have been implemented when the necessary orders/instructions putting the procedures detailed in this Agreement into effect have been issued to the forces concerned.



